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ABSTRACT

The four courses in this guide were designed to meet the specifications for the career orientation level of Illinois' Education for Employment Curriculum Model. These orientation-level courses can be taken by high school students in any sequence: (1) communication technology; (2) energy utilization technology; (3) production technology; and (4) transportation technology. Introductory materials include the following: scope and sequence; lists of integrated skills in transition, vocational ethics, and generalizable areas; state goals for learning; Technology Student Association; and how to use the curriculum guide and lesson plans. The communication technology course contains the following units: drafting and design, photography, graphic arts, processing and communicating information with computers, and telecommunications. The energy utilization course covers the following: energy conversion and transmission, fossil fuels and energy conservation, alternative energy systems, and solar energy. The following units are in the production technology course: materials and processes, construction, manufacturing, and servicing. Topics for the transportation technology course are the following: land transportation, materials handling, water transportation, air transportation, and space transportation. Each unit provides the following: rationale; mission statement; description; outline; unit titles; unit objectives; suggested learning objectives and experiences; and list of resources, including organizations, software, and print materials. (NLA)

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Industrial Technology Orientation Curriculum Guide

Illinois
State Board of
Education

Adult,
Vocational and
Technical Education

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Industrial Technology Orientation Guide

Illinois
State Board of
Education

Department of
Adult, Vocational
and Technical
Education

Thomas Lay Burroughs
Chairman

Vocational
Program Improvement
Section

Ted Sanders
State Superintendent
of Education

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Foreword

In the early 1980's, industrial technology teachers began to experiment with new, expanded content for their courses. This expansion resulted in a series of four courses with a technology emphasis. By 1984, this movement showed enough promise to motivate teachers to develop curriculum guides for each of the four one-semester courses (Communication Technology, Energy Utilization Technology, Production Technology, and Transportation Technology). These guides were disseminated to teachers throughout Illinois and teachers from other states relied on them as well.

Over the past few years, many teachers in Illinois have used the original curriculum guides. They have identified weaknesses and have offered suggestions for improvement. It soon became apparent that a new edition should be written.

The Industrial Technology Orientation Guide represents the efforts of many teachers. It includes new objectives and new suggested learning experiences. Just as importantly, it indicates the direct relationship the direction of these courses have to the State Goals for Learning. Therefore, this curriculum guide has the potential for improving the industrial technology curriculum. You are encouraged to use it to provide direction as you develop a comprehensive curriculum that will prepare students to live in a technological world.

Ted Sanders

Ted Sanders, Superintendent
Illinois State Board of Education

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Introduction

With the advent of the 80's the Illinois State Board of Education (ISBE), Department of Adult, Vocational and Technical Education (DAVTE) funded a comprehensive study of industrial education. The main purpose was to develop a model for industrial education that would best meet the needs of students preparing to live most of their lives in the Twenty-first Century. Advisory committees composed of representatives from business/industry and education were formed. After two years of gathering information, writing, reviewing, reacting, and revising, the Illinois Plan for Industrial Education evolved.

This was followed by the development of four curriculum guides in the areas of Communication Technology, Energy Utilization Technology, Production Technology, and Transportation Technology. These courses were originally developed in four public schools in Illinois and then tested in twelve different schools the following year. Finally, in 1984, curriculum guides were printed and disseminated throughout the state during the 1984-85 academic year. Subsequently, many teachers began to use the curriculum guides to provide direction for moving their traditional industrial education courses to more of a "technology" focus. Meanwhile, technology has changed and teachers have offered many suggestions. It soon became apparent that a revision was in order.

In FY 1988, a cadre of industrial technology teachers were assembled to evaluate the 1984 guides, consider the suggestions for improvement and to provide input into revised curriculum guides.

This document is the result of their efforts. It was written with the following objectives in mind.

- The guide should include a wide range of objectives that exemplify technology-based curriculum, emphasize content breadth versus depth, and reflect the need to teach resources, technical processes, industrial applications, and technological impacts.
- The guide should emphasize hands-on learning experiences that can be implemented in existing facilities with reasonable financial support, and the activities should motivate students to attain the unit objectives.
- The guide should contain learning experiences that further the opportunity to integrate generalizable skills, transition skills, and vocational ethics into the curriculum.
- The guide should suggest resources for obtaining textbooks, reference materials, instructional media, laboratory materials, and computer software that will support the implementation process.
- The guide should clearly correlate the objectives with the State Goals for Learning.
- The guide should portray the relationship orientation-level curriculum has with other Education for Employment curricula and provide a rationale, mission, and goals for courses at this level.
- The guide should suggest learning experiences that involve students in learning about a wide range of unskilled, semiskilled, skilled, technical, supervisory and professional careers.

Rationale for Change in Education

The undeniable constant in modern society is change. But that is not a new phenomenon! Society and education are in perpetual evolution. Consider the past century. One hundred years ago, nearly 75% of the population was engaged in production agriculture. There was a heavy reliance on animal and human energy. In this context, railroads were being built across the nation causing rapid expansion. This, in turn, created a need for an efficient method of providing a large number of people with the skills to use tools and machines of that era. **Manual training** became the answer. But the development continued. In the early 1900's, many followed the example of Henry Ford and built organizations that mass produced consumer goods, thereby rendering **manual training** inadequate. For some, the answer was to establish **trades and industry** (T & I) programs, for others, the answer was to add problem solving and design to the manual training curricula and call it **manual arts**.

About the same time, progressive educators like John Dewey advocated relevant, experiential learning — especially in a society attempting to educate the masses. This theory base coupled with the **manual arts** movement influenced the initiation of a general education program for a rapidly expanding industrial society called **industrial arts**. At first, this program consisted primarily of courses in woods, metals, and drafting, but later, such areas as electronics, energy and power, and graphic arts were added. As before, however, the needs within society continued to change. Now, in the 1980's, the percentage of the population engaged in production agriculture has dropped to less than three percent and, after reaching more than 60% in manufacturing (1950's), that number is also falling. It is predicted that by the year 2010, the number in manufacturing will be similar to that in agriculture. What has caused this major shift? **Technology**.

Technology has made it possible for a relatively few number of humans to produce our food. Likewise, fewer workers produce our goods because of advanced automation. However, that does not mean fewer people need to understand technology. To the contrary, all citizens are now constant users of technology. For example, humans can now engage in instant worldwide communication, travel faster than the speed of sound and produce durable goods using computer-controlled machines. Yes, technology has extended human potential, but for those who do not understand technology, it has also caused a high degree of *dependence*. When a given technology fails, many people must rely on a technician for assistance even though the problem may be minor. So, an understanding of technology can help make people less dependent.

Technology presents citizens with many choices. Many of these have a long term impact on society and the environment. How can the citizens of a democratic society make these choices unless they understand technology?

Technology is interdisciplinary in nature. The study of technology includes the application of principles and concepts from other subject areas. But it is more — it also involves the study of "techniques" — the science of efficient action. For example, pilots not only have an understanding of the principles of flight, they also know how to fly the aircraft. Almost all of the states have addressed this situation by changing their industrial arts programs to technology-based programs.

Here in Illinois, the Illinois Plan for Industrial Technology Education was developed in a long, but careful and deliberate, fashion. Using the question, **"what should *all* students know about technology so they are prepared to live productive lives in the Twenty-first Century?"** curriculum materials were designed, piloted, tested, disseminated and recently revised. While the Illinois Plan for Industrial Technology Education may be seen as a partial answer for the present, it can only maintain its vitality if teachers continually update the activities to assure they are current and relevant. It is up to the teachers to monitor societal needs and design activities accordingly.

Since **technology** has had, and continues to have, an enormous impact on our way of life, it seems appropriate that all persons should be able to understand and use **technology**. Industrial technology education (ITE) must meet this challenge.

The overall goal of ITE:

> to help students become technologically literate and equipped with the necessary skills to cope with, live in, and work in a highly industrial/technological society.

Objectives for orientation-level curriculum:

- to orient students to a wide range* of capital, human, and financial resources that support technology; to foundational skills and processes in industrial technology; and, to the application and impact of technology on the environment and society.
- to introduce students to a wide range of careers and vocational ethics in the curriculum.
- to help students achieve the State Goals for Learning that are necessary for their continued development.

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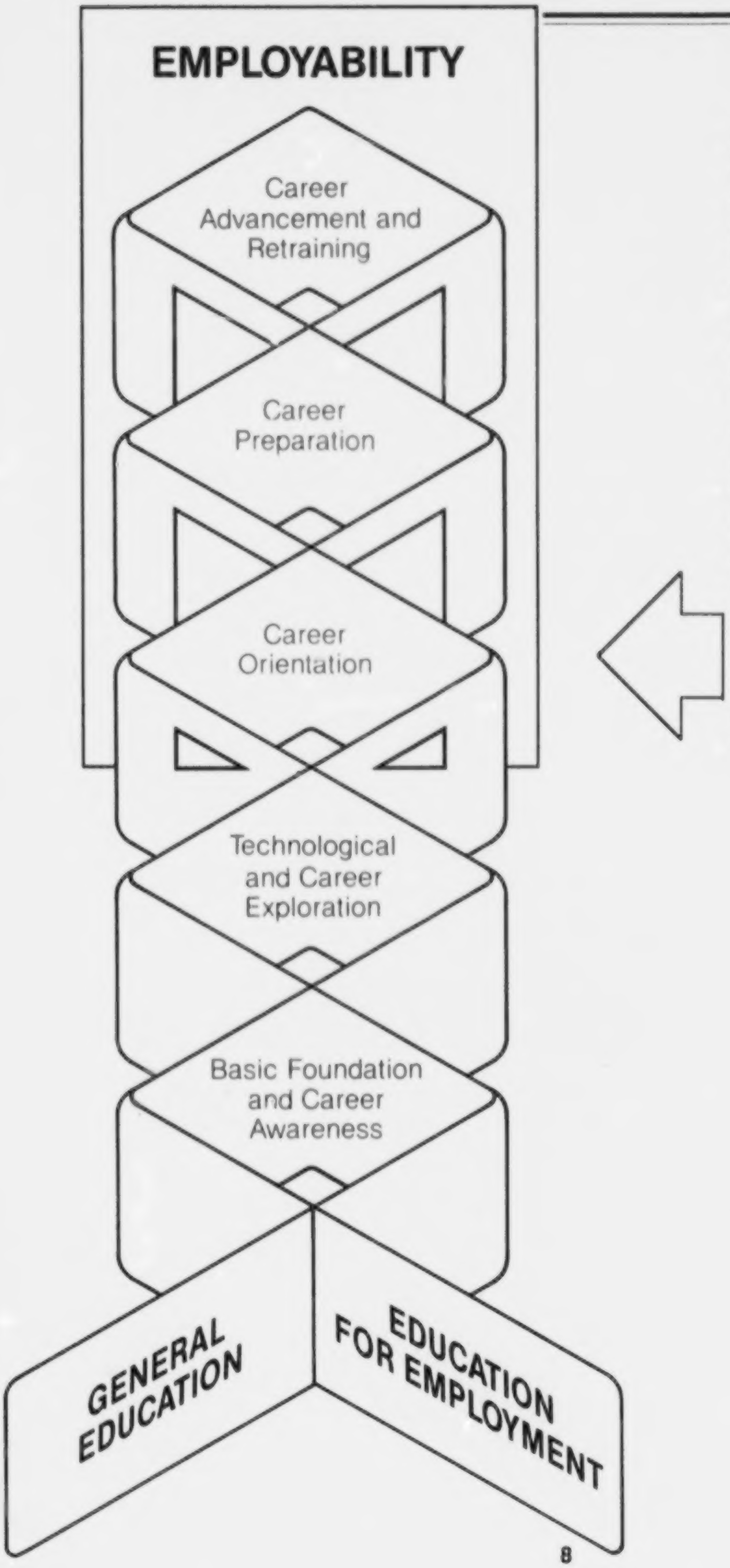
*The areas of Communication Technology, Energy Utilization Technology, Production Technology, and Transportation Technology should be included.


EMPLOYABILITY
Career Advancement and Retraining
Career Preparation
Career Orientation
Technological and Career Exploration
Basic Foundation and Career Awareness
GENERAL EDUCATION
EDUCATION FOR EMPLOYMENT

Scope and Sequence

The four, one semester (18 week) courses in this guide were designed to meet the specifications for the **orientation** level of the Education for Employment Curriculum Model. Curriculum developers should articulate the learning experiences at this level with those offered at the exploration level so key concepts can be reinforced and unwanted redundancy eliminated.

The four orientation level courses (Communication Technology, Energy Utilization Technology, Production Technology and Transportation Technology) can be taken by 9th-12th grade students in any sequence. Ideally, a student should take all four courses before proceeding to the preparation level. Because of their breadth, each course relates to all of the industrial programs at the preparation level.

Integrated Skills

Educators realize that teaching technical skills alone will not adequately prepare students to succeed in tomorrow's workplace. Students will also have to cope with such changes as retraining, re-education, new jobs, and changes in work relationships. Future workers must be able to independently solve problems as well as reason and communicate effectively. Students must learn mathematical and technological skills, and concepts and they must learn to think ethically and to act responsibly in a work environment. In short, students must be empowered to respond to their environment in such a way as to promote continuous and productive employment and satisfaction with life.

The **"Empowered Person Model"** (see next page) should be a central component of the Orientation Curriculum. It emphasizes a foundation of self-knowledge, including:

- awareness of one's own learning process;
- knowledge of personal values;
- styles for thinking and feeling.

Empowered persons resolve challenges that they face in the environment by using:

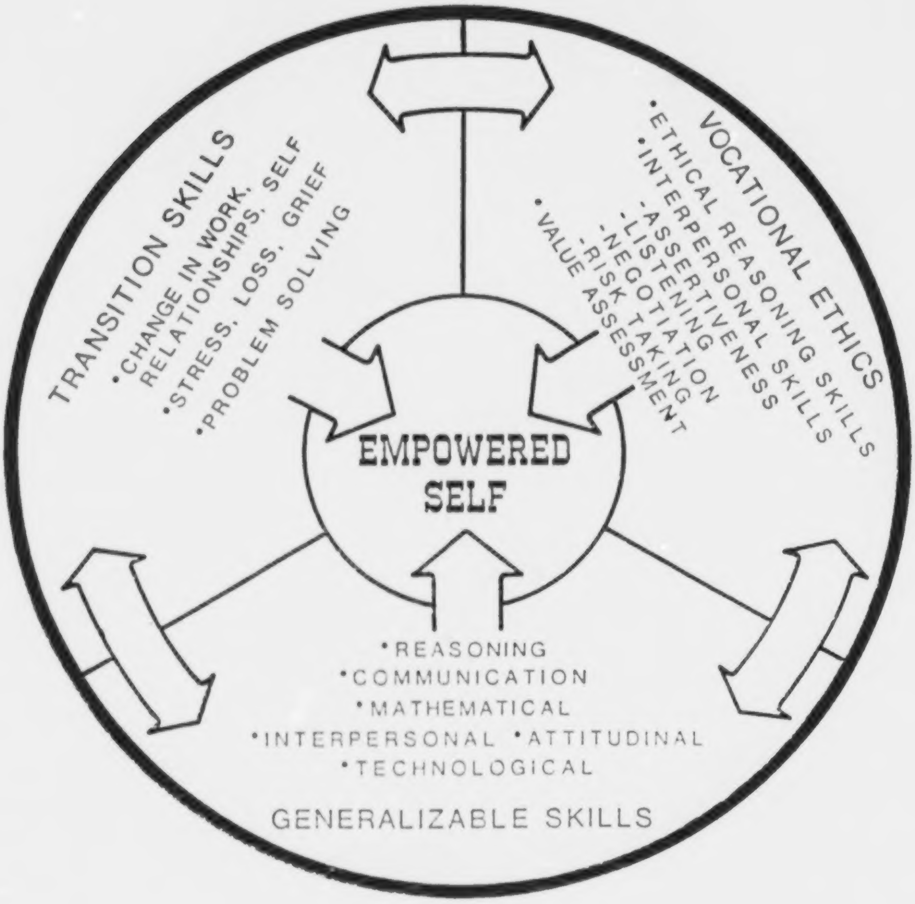
Transition Skills

- Managing life transitions, especially those that impact directly or indirectly on one's occupation (e.g., becoming educated, choosing a career, finding a first job, changing jobs).
- Managing changes in environment, relationships, and self (e.g., leaving parents, deciding to marry, having children, seeking individual identity).
- Managing stress, loss and grief (e.g., work overload, illness, loss of income, loss of loved one).
- Making decisions (e.g., whether to move up to a supervisory position, whether to change career fields, whether to retire).

Vocational Ethics Skills

- Ethical reasoning skills are employed to objectively analyze choices and decisions according to value assessment criteria: reciprocity, consistency, coherence, comprehensiveness, adequacy, and duration.
- Interpersonal behavior skills are required for individuals to successfully implement ethical choices: assertiveness, empathic listening, negotiation, and risk taking.
- An enabling work ethic is a flexible system of beliefs, values, and principles used by the individual to resolve personal and interpersonal work-related ethical issues and problems (e.g., whether to tell the boss that you saw your best friend take money from the cash register on several different occasions, or whether to let the boss find out some other way).

SKILLS FOR THE ADAPTIVE PERSON


TRANSITION SKILLS
•CHANGE IN WORK, SELF
RELATIONSHIPS,
•STRESS, LOSS, GRIEF
•PROBLEM SOLVING
VOCATIONAL ETHICS
•ETHICAL REASONING SKILLS
•INTERPERSONAL SKILLS
-ASSERTIVENESS
-LISTENING
-NEGOTIATION
-RISK TAKING
•VALUE ASSESSMENT
EMPOWERED SELF
•REASONING
•COMMUNICATION
•MATHEMATICAL
•INTERPERSONAL •ATTITUDINAL
•TECHNOLOGICAL
GENERALIZABLE SKILLS

Generalizable Skills

- Those skills which are actively used in work performance.
- Those skills which are transferable across jobs and occupations.
- Those skills which are instrumental to success on the job and in the classroom.
- Those skills, including the three R's — reading, writing, and arithmetic — that are crucial for adapting to change.

Individuals become empowered by using transition skills, vocational ethics skills, and generalizable skills to effectively meet challenges they face in the environment.

Teachers can encourage students to develop a greater degree of self-empowerment by:

- Acting as a role model, guide, collaborator, and facilitator.
- Assuming the role of "the most experienced learner."
- Introducing students to a process of solving real problems and challenges.
- Integrating transitional skills, vocational ethics skills, and generalizable skills into their instruction.

Transitional skills can be introduced by having students complete four steps:

Step 1: Identify Transitions

It is important for people to recognize when they are in transition (i.e., youth crisis, a mid-life crisis, or a retirement crisis) so they can cope and manage the situation.

Step 2: Identify Coping Resources

This step involves identifying coping resources such as support systems (i.e., family and/or friends), identifying personal strengths and values which will assist in handling transitions. The process of coping with transitions has the potential for both growth or retreat, movement or stagnation, affirmation or resignation. An individual can learn to effectively manage transitions through a renewal process of setting new goals and directions.

Step 3: Identify and Choose Ways of Managing Transitions.

To deal constructively with transitions, people need to use a problem solving model to make effective decisions. Basically, problem solving becomes a way of ordering one's thoughts and resources and searching out a viable course of action. The purpose of systematic, active problem solving is to gain a sense of control and competence at a time when critical aspects of life are in a state of transition. Problem solving involves:

- identifying the problem
- exploring alternatives
- selecting and planning a course of action.
- implementing the course of action.
- evaluating the action, learning.

Step 4: Action, Feedback, and Self-Transformation

This step first involves action. The objective is to gain awareness of the effectiveness of the transition decisions and to apply acquired knowledge to new transitions. Endings of what has been, the period and confusion of the in-between, and the shaping of the new beginning are the rhythm of the transition process.

Because we are social beings, the methods we use to manage transitions, and the many decisions we make, directly affects the people around us. Our relationship with people we work for or work with, or who are influenced by our work depends on the quality of decisions we make when faced with difficult choices.

Choices which affect others are, in fact, ethical decisions. Vocational ethics teaches people to make ethical decisions and is an important part of self-empowerment because it enables people to have continuous and satisfying social and working relationships.

The teaching of **vocational ethics** is educating for and toward the development of an enabling work ethic. An enabling work ethic is an integrated and interactive system of attitudes, values, and beliefs that empowers workers to sustain long-term job satisfaction and productive employment.

The content of vocational ethics instruction focuses on two main types of skills to be acquired by students:

- ethical reasoning skills.
- interpersonal skills.

The teacher serves both as a model and facilitator as ethical situations are presented and discussed in a problem solving format. Teachers encourage students to generate a variety of alternatives for solving the problems and evaluate each solution using the following value assessment criteria.

- Reciprocity: Would you want this choice made if you were in another participant's place?
- Consistency: Would this choice be appropriate for you to make in other similar circumstances?
- Coherence: Would this choice contribute to the overall well-being of the group or organization of which you are a part?
- Comprehensiveness: Would this choice be appropriate for everyone to make in other similar situations?
- Adequacy: Would this choice solve the short-term problem?
- Duration: Would this choice solve the problem over time?

Students benefit from ethical problem solving in a classroom situation. They develop an awareness of the relative adequacy of each solution that is evaluated leading to either altered or affirmed work attitudes, values, and beliefs. Thus, students become more aware of the consequences of various choices as well as the diversity of opinion on ethical issues held by others.

Beyond giving students skills for analyzing ethical issues, they should be encouraged to develop the behavioral skills needed to implement decisions successfully. This requires that they possess the four following primary types of interpersonal skills:

- Assertiveness: Assertiveness is defined as the ability to stand up for one's rights and to express oneself fully without infringing on the rights of others. Assertiveness skills are techniques that people can learn for achieving goals of self-expression.
- Empathic listening: Listening well is a skill that must be developed and practiced like any other. It begins with active listening. It also involves the listener's attention to such body language as facial expression, posture, and tone of voice.
- Principled negotiation: The object of principled negotiating is not to win the largest slice of the pie, but to work together for an agreement which solves a problem in a way that is fair to all parties.
- Risk taking: This skill involves assessing the expected utility of a certain course of action. Once individuals comprehend the elements that make up a situation and correctly determine the chances for success or failure, they will be better able to execute a risky action.

During recent years, increased public attention has focused on additional skills and ability needed to participate in our society. In particular, the field of vocational education has begun to focus attention in the area of basic, or generalizable skills.

Employers have noted the importance of providing students with the basic skills necessary for entry-level employment and have stated that reading, writing, mathematics, and interpersonal skills are especially important. **Generalizable skills** are critical to employability and occupational competence because they are transferable to a broad range of occupations, and they also form the necessary foundation upon which higher order skills are learned.

Most recently, the ideas of basic skills, transferable skills, and the skills and abilities needed for success in vocational programs and occupations have been conceptualized in terms of generalizable skills. A generalizable skill is one which is basic to, necessary for success in, and transferable (or common) within or across vocational programs.

Through mastery of the generalizable skills, an individual is able to become empowered by purposefully acting to improve personal conditions or situations in both educational settings and the workplace. Four major categories of generalizable skills have been described: communication skills, interpersonal skills, mathematical skills, and reasoning skills. The opportunities to stress these skills in the industrial technology laboratory are readily available. The lesson plan format suggested later in this guide has been designed to remind the teachers to capitalize on these opportunities.

Mathematics Skills

- Read, write, and count single and multiple digit whole numbers.
- Add and subtract single and multiple digit whole numbers.

- Multiply and divide single and multiple digit whole numbers.
- Use addition, subtraction, multiplication, and division to solve word problems with single and multiple digit whole numbers.
- Round off single and multiple digit whole numbers.

Fractions

- Read and write common fractions.
- Add and subtract common fractions.
- Multiply and divide common fractions.
- Solve word problems with common fractions.

Decimals

- Carry out arithmetic computations involving dollars and cents.
- Read and write decimals in one or more places.
- Round off decimals to one or more places.
- Multiply and divide decimals in one or more places.
- Add and subtract decimals on one or more places.
- Solve word problems with decimals in one or more places.

Percent

- Read and write percents.
- Compute percents.

Mixed Operations

- Convert fractions to decimals, percents to fractions, fractions to percents, percents to decimals, decimals to percents, common fractions or mixed numbers to decimal fractions, and decimal fractions to common fractions or mixed numbers.
- Solve word problems by selecting and using correct order of operations.
- Perform written calculations quickly.
- Compute averages.

Measurement and Calculation

- Read numbers or symbols from time, weight, distance, and volume measuring scales.
- Use a measuring device to determine an object's weight, distance, or volume in standard (English) units.
- Use a measuring device to determine an object's weight, distance, or volume in metric units.
- Perform basic metric conversions involving weight, distance, and volume.
- Solve problems involving time, weight, distance, and volume.
- Use a calculator to perform basic arithmetic operations to solve problems.

Estimation

- Determine if a solution to a mathematical problem is reasonable.

Communication Skills

Words and Meanings

- Use plural words appropriately in writing and speaking.
- Use appropriate contractions and shortened forms of words by using an apostrophe in writing and speaking.
- Use appropriate abbreviations of words in writing and speaking.
- Use words appropriately which mean the same as other words but are spelled differently.
- Use words correctly which sound the same as other words but that have different meanings and spellings.
- Use words appropriately which are opposite of one another.
- Use appropriate word choices in writing and speaking.
- Add appropriate beginnings and endings to words to change their meaning.
- Punctuate one's own correspondence, directives, or reports.

Reading

- Read, understand, and find information or gather data from books, manuals, directories, or other documents.
- Restate or paraphrase a reading passage to confirm one's own understanding of what was read.
- Read and understand forms.
- Read and understand short notes, memos, and letters.
- Read and understand graphs, charts, and tables to obtain factual information.
- Understand the meanings of words in sentences.
- Use a standard dictionary to obtain the meaning, pronunciation, and spelling of words.
- Use the telephone and look up names, telephone numbers, and other information in a telephone directory to make local and long distance calls.

Writing

- Review and edit other's correspondence, directives, or reports.
- Compose logical and understandable written correspondence, directives, memos, short notes, or reports.
- Write logical and understandable statements, phrases, or sentences to accurately fill out forms.

Speaking

- Speak fluently with individuals or groups.
- Pronounce words correctly.
- Speak effectively using appropriate behaviors such as eye contact, posture, and gestures.

Listening

- Restate or paraphrase a conversation to confirm one's own understanding of what was said.
- Ask appropriate questions to clarify another's written or oral communications.

- Attend to nonverbal cues such as eye contact, posture, and gestures for meanings in other's conversations.
- Take accurate notes which summarize the material presented from spoken conversations.

Interpersonal Relations Skills

Work Behaviors

- Work effectively under different kinds of supervision.
- Work without the need for close supervision.
- Work cooperatively as a member of a team.
- Get along and work effectively with people of different personalities.
- Show up regularly and on time for activities and appointments.
- Work effectively when time, tension, or pressure are critical factors for successful performance.
- See things from another's point of view.
- Engage appropriately in social interaction and situations.
- Take responsibility and be accountable for the effects of one's own judgments, decisions, and actions.
- Plan, carry out, and complete activities at one's own initiation.

Instructional and Supervisory Conversations

- Instruct or direct someone in the performance of a specific task.
- Follow instructions or directions in the performance of a specific task.
- Demonstrate to someone how to perform a specific task.
- Assign others to carry out specific tasks.
- Speak with others in a relaxed and self-confident manner.
- Compliment and provide constructive feedback to others at appropriate times.

Conversations

- Be able to handle criticism, disagreement, or disappointment during a conversation.
- Initiate and maintain task focused or friendly conversations with another individual.
- Initiate, maintain, and draw others into task focused or friendly group conversations.
- Join in task focused or friendly group conversations.

Reasoning Skills

Verbal Reasoning

- Generate or conceive of new or innovative ideas.
- Try out or consciously attempt to use previously learned knowledge and skills in a new situation.
- Understand and explain the main idea in another's written or oral communication.
- Recall ideas, facts, theories, principles, and other information accurately from memory.

- Organize ideas and put them into words rapidly in oral and written conversations.
- Interpret feelings, ideas, or facts in terms of one's own personal viewpoint or values.
- State one's point of view, opinion, or position in written or oral communication.
- Defend one's point of view, opinion, or position in written or oral communication.
- Distinguish between fact and opinion in one's own and in other's written and oral communication.
- Identify the conclusions in other's written or oral communication.
- Identify the reasons offered by another and evaluate their relevance and strength of support for a conclusion.
- Compile one's own notes taken on several written sources into a single report.
- Compile ideas, notes, and materials supplied by others into a single report.
- Carry out correctly written or oral instructions given by another.
- Observe another's performance of a task to identify whether the performance is satisfactory or needs to be improved.
- Ask questions about another's performance of a task to identify whether the performance is satisfactory or needs to be improved.

Problem Solving

- Recognize or identify the existence of a problem given a specific set of facts.
- Ask appropriate questions to identify or verify the existence of a problem.
- Enumerate the possible causes of a problem.
- Use efficient methods for eliminating the causes of a problem.
- Judge the credibility of a source of information.
- Identify important information needed to solve a problem.
- Identify other's and one's own assumptions relating to a problem.
- Generate or conceive of possible alternative solutions to a problem.
- Describe the application and likely consequences of possible alternative problem solutions.
- Compare the application and likely consequences of alternative problem solutions and select a solution that represents the best course of action to pursue.

Planning

- Sort objects according to similar physical characteristics including shape, color, and size.
- Estimate weight of various objects of different shapes, sizes and make-up.
- Estimate length, width, height, and distance between objects.
- Use the senses of touch, sight, smell, taste, and hearing.
- Set priorities or the order in which several tasks will be accomplished.

- Set the goals or standards for accomplishing a specific task.
- Enumerate a set of possible activities needed to accomplish a task.
- Determine how specific activities will assist in accomplishing a task.
- Select activities to accomplish a specific task.
- Determine the order of the activities or step-by-step process by which a specific task can be accomplished.
- Estimate the time required to perform activities needed to accomplish a specific task.
- Locate information about duties, methods, and procedures to perform the activities needed to accomplish a specific task.
- Locate information and select the materials, tools, equipment, or other resources to perform the activities needed to accomplish a specific task.
- Revise or update periodically plans and activities for accomplishing a specific task.

State Goals for Learning

Educational reform legislation of 1985 provides for the development of learning goals and assessment systems at both the state and local levels. The State Goals for Learning are broadly stated, relatively timeless expressions of what students are expected to know and do as a consequence of their elementary and secondary schooling. Although these goals are divided into the areas of language arts, mathematics, biological and physical sciences, social sciences, fine arts and physical development and health; **industrial technology orientation level courses do help students achieve many of these goals**. It is the responsibility of the industrial technology teacher to identify the objectives in their courses that help students achieve these goals. The objectives in this guide were carefully reviewed and many of them were determined to have a direct relationship to the State Goals for Learning. They are identified with a special code as specified in the following listing. Those in bold are addressed by the objectives in this guide

Language Arts

As a result of their schooling, students will be able to:

LA1 **read, comprehend, interpret, evaluate and use written material;**
LA2 listen critically and analytically;
LA3 **write standard English in a grammatical, well-organized and coherent manner for a variety of purposes.**
LA4 **use spoken language effectively in formal and informal situations to communicate ideas and information and to ask and answer questions.**
LA5 understand the various forms of significant literature representative of different cultures, eras, and ideas;
LA6 understand how and why language functions and evolves.

Mathematics

As a result of their schooling, students will be able to:

MA1 **perform the computations of addition, subtraction, multiplication, and division using whole numbers, integers, fractions and decimals;**
MA2 **understand and use ratios and percentages.**
MA3 **make and use measurements, including those of area and volume;**
MA4 **identify, analyze and solve problems using algebraic equations, inequalities, functions and their graphs;**
MA5 **understand and apply geometric concepts and relations in a variety of forms;**
MA6 **understand and use methods of data collection and analysis, including tables, charts and comparisons;**
MA7 use mathematical skills to estimate, approximate, and predict outcomes and to judge reasonableness of results.

Biological and Physical Sciences

As a result of their schooling, students will have a working knowledge of:

SC1 **the concepts and basic vocabulary of biological, physical and environmental sciences and their application to life and work in a contemporary technological society;**
SC2 **the social and environmental implications and limitations of technological development;**
SC3 the principles of scientific research and their application in simple research projects;
SC4 **the processes, techniques, methods, equipment and available technology of science;**

Social Sciences

As a result of their schooling, students will be able to:

SS1 **understand and analyze comparative political and economic systems, with an emphasis on the political and economic systems of the United States;**
SS2 **understand and analyze events, trends, personalities, and movements shaping the history of the world, the United States and Illinois;**
SS3 demonstrate a knowledge of the basic concepts of the social sciences and how these help to interpret human behavior;
SS4 demonstrate a knowledge of world geography with emphasis on that of the United States;
SS5 apply the skills and knowledge gained in the social sciences to decision making in life situations.

Fine Arts

As a result of their schooling, students will be able to:

FA1 **understand the principal sensory, formal, technical and expressive qualities of each of the arts;**
FA2 identify processes and tools required to produce visual art, music, drama and dance;

FA3 demonstrate the basic skills necessary to participate in the creation and/or performance of one of the arts;
FA4 identify significant works in the arts from major historical periods and how they reflect societies, cultures and civilizations, past and present;
FA5 describe the unique characteristics of each of the arts.

Physical Development and Health

As a result of their schooling, students will be able to:

PH1 understand the physical development, structure, and functions of the human body;
PH2 understand principles of nutrition, exercise, efficient management of emotional stress, positive self-concept development, drug use and abuse, and the prevention and treatment of illness;
PH3 **understand consumer health and safety, including environmental health;**
PH4 demonstrate basic skills and physical fitness necessary to participate in a variety of conditioning exercises or leisure activities such as sports and dance;
PH5 plan a personal physical fitness and health program;
PH6 **perform a variety of complex motor activities;**
PH7 demonstrate a variety of basic life-saving activities.

Student Organizations

Using Student Organizations:

Teachers and students benefit greatly from incorporating student organization activities into the everyday operation of an orientation-level class. Technology Student Association (TSA) activities can be integrated into a 9th or 10th grade course and be utilized in conducting and organizing classroom and laboratory activities. For information concerning the initiation of a charter for a TSA Chapter in your school, call the Industrial Consultants at the DAVTE (217/782-4877).

An effective method to integrate TSA activities into each classroom and laboratory is through a personnel management system. TSA provides a tool for managing activities using a democratic decision-making process. Class officers can become the facilitators in the organization of each class. They can become responsible for roll taking, record keeping, inventory control, laboratory maintenance, student evaluation, and public relations.

Various committees can be formed in which students become involved in planning or conducting activities in the classroom or laboratory. The Industrial/Community Resource Committee can identify and arrange appropriate speakers for class. The School/Community Service Committee can be held responsible for finding possible projects to benefit the classroom, school, or community. The Recognition of Achievement Committee can work with the teacher to select and develop TSA contests relating to the units of study. This committee can organize the chapter's involvement in Regional, State, and National competitions. Handled properly, this can become a highly motivational aspect of the course, as well as provide program visibility in the school, community, state and/or nation.

The integration of TSA into your program has the potential to help students in many ways, including the ability to:

- lead, follow, and make decisions;
- accept civic and citizenship responsibilities;
- experience the free enterprise system;
- interact with business and industrial leaders;
- explore industrial and technical careers; and
- receive recognition through achievement programs.

In addition, the teacher benefits from the use of a student organization in the classroom because he/she becomes not only a traditional "demonstrator," "lecturer," or "teller," but in addition, a facilitator and consultant. Student organization activities are effective teaching tools that:

- provide interesting curricular and chapter activities;
- highlight leadership training experiences;
- assist students in making informed and meaningful choices;
- promote related subject areas in the school, community, state, and nation;
- motivate students toward higher levels of achievement; and
- provide for wholesome competition.

Consider the merits such an organizational structure can place on your program, and integrate TSA activities into your classroom and laboratory. It can **enhance** your industrial technology program.

Using the Curriculum Guide

Since technology is having such a dramatic impact on the way humans produce goods and structures, transport people and products, and communicate graphically and/or electronically, it is appropriate that these three human activities become the focus of attention. Additionally, in the state of Illinois where 80% of the energy dollar is exported to other states, and since energy is such a necessary ingredient in **production, transportation, and communication,** the fourth course title has been designated **energy utilization.** Although some schools have chosen to integrate these four technological systems into one thirty-six week course with approximately nine weeks devoted to each topic, the more optimum arrangement is to devote one full semester to each of these areas.

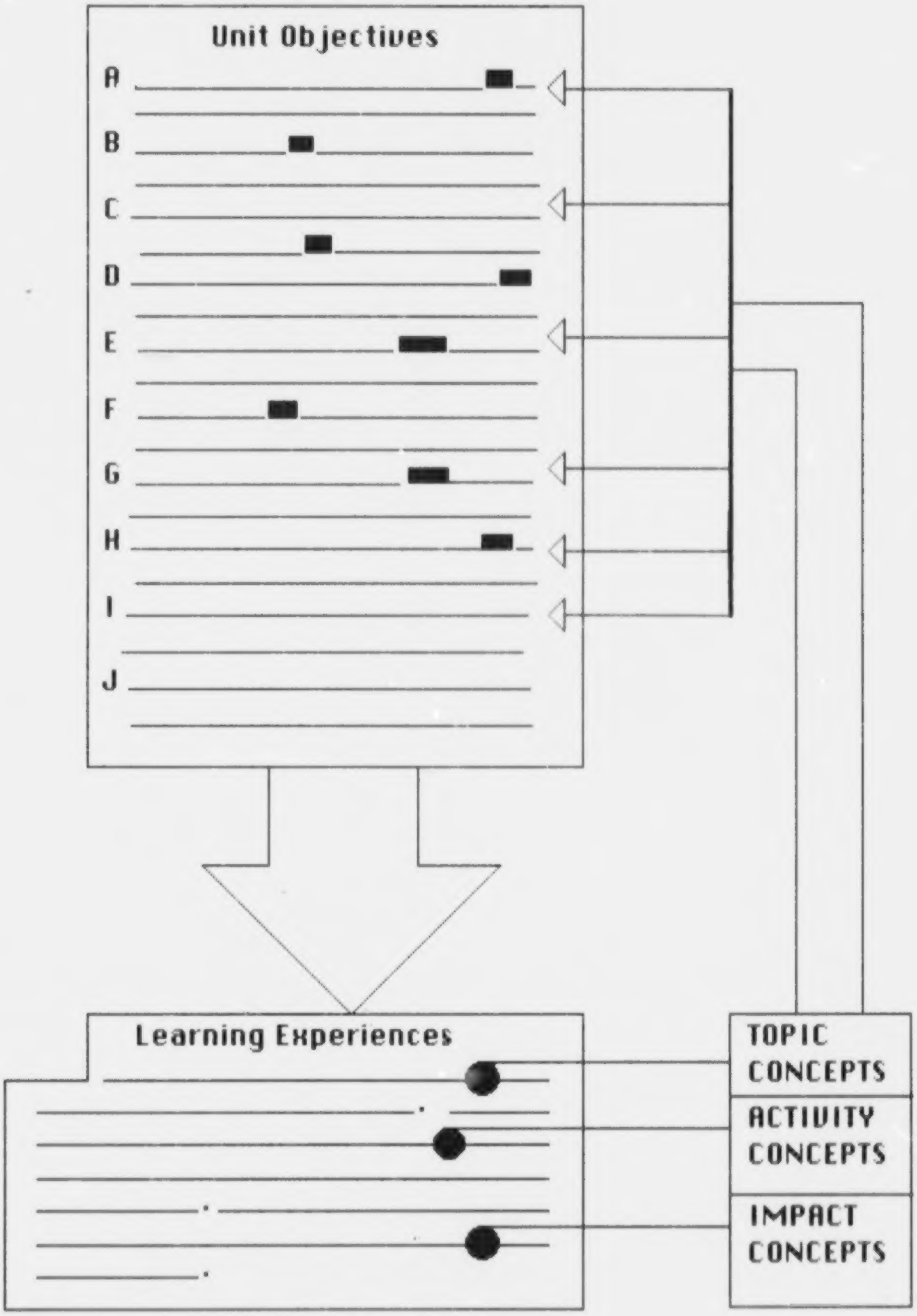
In addition to course titles, each course includes a rationale, mission statement, description, and outline. These components are provided to assist the teacher in meeting the technology education challenge. For example, the rationale, mission statements, course descriptions and outlines can be used to enhance communication with school board members, administrators, parents, teachers, guidance counselors, and students.

Each course also contains suggested unit titles. In order to have a fuller understanding of each technological system, all of the units should be included in the course. The objectives for each unit are structured around technological concepts. Some of the objectives feature conceptual themes (in bold type) that support the study of technology in general. Other objectives focus on concepts unique to a given technology. While each objective provides direction for planning technology-based curricula, they are not totally inclusive. Classroom teachers are encouraged to expand and tailor the objectives to meet the unique needs of their students. To support the study of Industrial Technology in the general education curriculum, many of the objectives have been articulated with the State Goals for Learning. When using the broad objectives to develop specific daily lesson objectives, an attempt should be made to continue to reinforce one or more of the State Goals. In addition, teachers should address Integrated Skills (transition skills, vocational ethics, generalizable skills).

Following the unit objectives, a variety of suggested learning experiences are provided. Some learning experiences were designed to be used as "stand alone" activities. Others have been designed into a series of activities. Their purpose is to provide the classroom teacher with ideas as to how they might involve students in achieving the unit objectives. Three conceptual components have been integrated into each learning experience. Typically, the first sentence contains one or more topic concepts. The middle sentence(s) suggests one or more activity concept(s). The last sentence or two incorporate one or more impact concepts. Therefore, each learning experience embraces many of the unit objectives. In this way, the guide provides direction to the classroom teacher but also flexibility when designing lessons. The relationship between the objectives, concepts and learning experiences is illustrated on the next page.

Finally, this guide provides a listing of resources for teachers to utilize as they continue the planning process. Each course contains information pertaining to curriculum reference materials, computer software, books, and manuals.

Relationship between unit objectives and the suggested learning experiences


Unit Objectives
A
B
C
D
E
F
G
H
I
J
Learning Experiences
TOPIC CONCEPTS
ACTIVITY CONCEPTS
IMPACT CONCEPTS

Using the Lesson Plan

After becoming totally familiar with the unit objectives and the suggested learning experiences, teachers should then begin the planning process at the local level. This planning is heavily dependent upon facilities, teacher expertise, class size, student needs, etc. The lesson plan format contained in this guide (see page 26) will provide guidance through this process.

First of all, enter the course and unit titles. Typically, there will be a number of lesson plans within a unit. Likewise, some learning experiences will require more than one lesson plan. Also, estimate the time required to complete the lesson. This will help to pace the instruction so that each topic receives the attention it deserves and is included in the unit.

The next step is to determine the lesson objectives. These should include the conditions, the expected student outcome written in performance terms, and the level of performance. The suggested **learning experiences** provided in the curriculum provide direction as the daily objectives are determined. For example, the first sentence suggests one or more "knowing" objective(s). The middle sentence(s) suggests one or more objectives that involve the students in "doing" a series of multiple activities that cause students to actually apply this new knowledge to the real world situation. And the last sentence suggests how this knowledge and the processes impact society and the environment.

The learning activities section of the lesson plan includes two distinct parts. First, there is a space for an outline of the teacher responsibilities during the lesson. It is assumed that demonstration outlines, content outlines, transparencies, project ideas, etc. will be attached to the lesson plan. Likewise, student activities must be considered. Teachers are encouraged to involve students in actual planning, decision making, problem solving, etc. Again, it is assumed that the handouts students would use would be attached to this lesson plan.

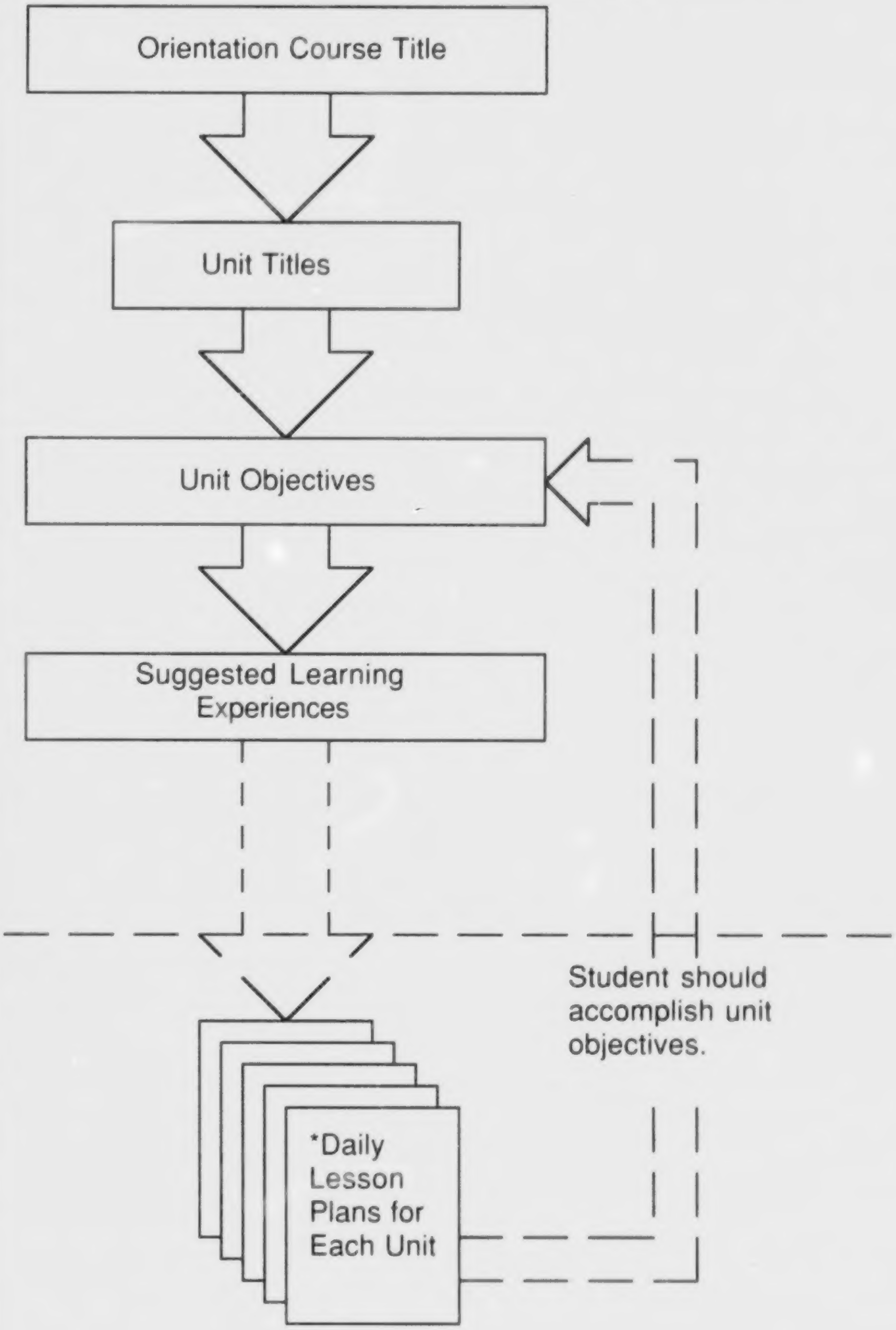
An evaluation component for each lesson is essential. In this way, the students can receive immediate feedback as to whether or not they have achieved the objectives. This also gives the teacher an idea of the effectiveness of the lesson. It is important to note, when evaluating technology-based materials more attention should be placed on a student's conceptual knowledge and understanding of the material and less on a student's ability to perform manual skills.

The section, Tools, Materials, Machines and Resources, on the Lesson Plan format is simply provided to remind the instructor whether or not everything is in readiness so a successful lesson will occur.

Finally, a checklist is provided to remind the instructor to include a series of integrated skills as lessons are planned. Refer to the "Integrated Skills" section of this guide for a complete description of these skills. A conscience effort on the part of the teacher to include these skills will maximize the value of each learning activity.

COURSE DEVELOPMENT PROCESS

This curriculum guide includes the general, more global parts of a course of study.


Orientation Course Title
Unit Titles
Unit Objectives
Suggested Learning Experiences
*Daily Lesson Plans for Each Unit

Student should accomplish unit objectives.

Lesson plans should be based on local conditions such as facilities, time, student needs, class size, etc.

*Format on next page

DAILY LESSON PLAN

Course Title ______________________ DATE ____________

Lesson Topic ____

Time Estimate ______________ Unit ______________

Lesson Objectives: **The student will be able to:**

Know ____

Do ____

Apply ____

Learning Activity:

Teacher Responsibility	Student Activity

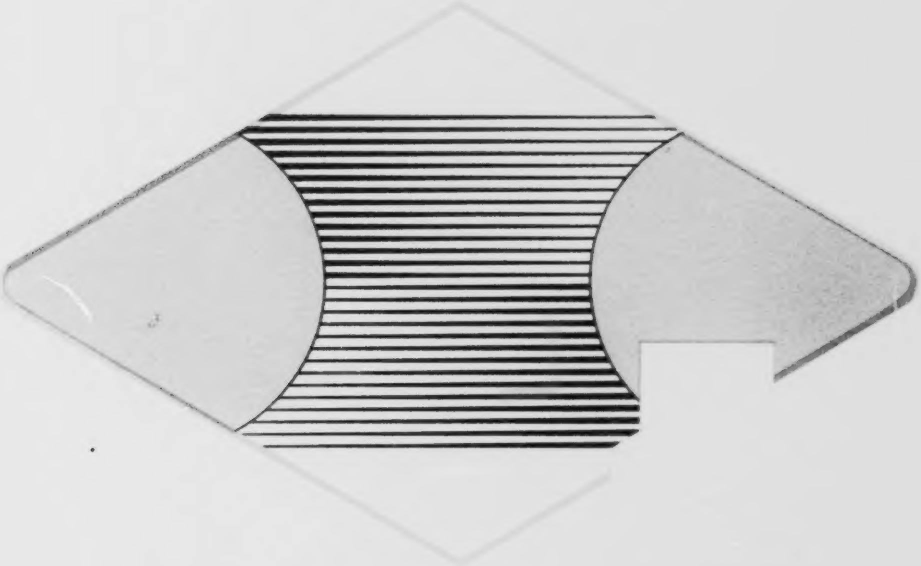
Evaluation:

Tools, Materials, Machines, Resources needed:

Integrated Skills: (Generalizable Skills, Transition Skills, and Vocational Ethics)

- ☐ Reasoning
- ☐ Communication
- ☐ Mathematical
- ☐ Technological
- ☐ Attitudinal
- ☐ Identify Careers
- ☐ Determine Appropriate
- ☐ Demonstrate Appropriate Work Behavior
- ☐ Make Environment Safe
- ☐ Maintain Businesslike Image
- ☐ Change in work, relationships, self
- ☐ Stress, loss, grief
- ☐ Problem solving
- ☐ Ethical Reasoning
- ☐ Interpersonal Skills:
  - ☐ Assertiveness
  - ☐ Listening
  - ☐ Negotiation
  - ☐ Risk Taking

Communication
Technology
Curriculum Guide



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COMMUNICATION TECHNOLOGY

Course Rationale

It has been said that our society is in the midst of an "Information Age." This statement is based on the rapid development of communication technology over the past several decades.

Examples of communication technology can be seen throughout all facets of our daily lives, from making routine phone calls, printing newspapers, or broadcasting television programs. Those daily events have been available for quite some time, but the means by which they are done or the method by which they are made available has changed dramatically. Today's phone calls can be made on the move using cellular phones. Phone calls can be networked allowing simultaneous communication from various locations in the world. Newspaper articles can be written and quickly edited using computers and desktop publishing programs. Once the newspaper is completed, it can be sent over fiber optic cable and displayed on a home monitor. Satellite and cable television can provide us access to instant news coverage, a wide variety of entertainment programs, and an opportunity to obtain an education at home.

Through the development of the computer, communications technologies like drafting, graphic arts and photography have undergone significant change. Computers have made it possible for designers to create computer-aided drawings that can be edited quickly, rotated to any angle, magnified to various sizes, and displayed in full 3-D. Computer technology has replaced tedious and time consuming graphic arts processes with accurate and efficient laser printers. Automatic cameras now make it possible for everyone to take pictures like a professional. Video recorders and cameras enable people to record and again experience important events.

Since the capabilities of existing communication systems has expanded so rapidly, it has become increasingly important to learn how to utilize technology to record, send, receive, and process information. We are living in an "Information Age" and have become a society that seeks new and better ways to communicate. It is education's responsibility to teach students how to adapt, cope, and use this new emerging technology.

Course Mission

The purpose of the Communication Technology course is to orient students to the basic resources, technical processes, industrial applications, and technological impacts in both graphic and electric means of transmitting and receiving information. The course will help students to:

- use and understand the verbal and symbolic language used to describe communication systems and phenomena;
- develop and present creative solutions to present and future communication problems;

- identify and investigate potential career opportunities in the area of communication;
- understand the evolution of communication technology and its influence on our culture; and
- safely use common tools, materials and processes to design, build, and test communication systems.

Course Description

The Communication Technology course includes units on drafting and design, photography, graphic arts, telecommunication, and processing and communicating information with computers. Each unit will involve students in a wide range of learning activities and experiences. Include things like generating a simple floor plan, conducting a photo session, reproducing a graphic product, creating computer-aided graphics, and making a video tape.

Course Outline

In the spirit of orientation, students should be introduced to a wide range of graphic and electronic communication technologies. The following course outline lists the recommended units for either a nine or an eighteen week format. Potential lesson topics are provided under each unit title. Each lesson should embrace as many of the unit objectives as possible. In a nine week format, an emphasis should be placed on the terminology, resources, processes, applications, impacts, career and safety concepts that relate to the lesson topic.

Sample Communication Technology Course Outline

I. Introduction to Communication Technology

II. Drafting and Design
    A. Sketching
    B. Multiview
    C. Pictorial
    D. Architectural
    E. Charts and Graphs
    F. Schematics
    G. Maps

III. Photography
    A. Cameras and film
    B. Photographing subjects
    C. Processing photographs
    D. Presenting photographs

IV. Graphic Arts
    A. Graphic arts enterprises
    B. Establishing formats
    C. Writing messages

    - D. Illustrating messages
    - E. Preparing and processing copy
    - F. Reproducing graphic products
    - G. Distributing graphic products

V. Processing and Communicating Information with Computers
    - A. Hardware
    - B. Software
    - C. Applications

VI. Telecommunication
    - A. Telephone
    - B. Radio
    - C. Television
    - D. Fiber Optics
    - E. Satellites

Adapting the Communication Technology Course Outline to Nine or Eighteen Week Formats

Hands-on learning activities are one of the most powerful ways of helping students learn about technology. Unfortunately, they are very time consuming. The following strategies can be employed to use available laboratory time more efficiently without sacrificing important unit objectives:

- Divide the class into small groups and assign each group a different learning activity related to the lesson topic. When each group has finished their assigned activities, have students present their experiences to the rest of the class. For example, during the computer unit, have each group use and present a software package designed for a given application.
- Avoid assigning complex laboratory activities when simpler activities will enable students to experience important concepts and achieve the desired objectives. For example, during the graphic arts unit, have students design and reproduce a poster instead of a multipage newsletter.
- Prepare work stations that organize the tools and materials needed to conduct laboratory activities prior to class. For example, during the telecommunication unit, develop radio kits that students can assemble and test.
- Have students experience a wide range of concepts through one or two robust learning activities. For example, during the telecommunications unit, have students make a video tape. Discuss how the basic parts of a television system (e.g., input transducer, transmitter, link, receiver, output transducer) transfer to radio and telephone communication systems.

During an eighteen week format, students can engage in more complex learning activities and experience given topics in greater depth. In addition, there is an opportunity to provide a wider range of learning experiences. The study of technology allows for an infinite number of learning experiences. Therefore, it is important to select and implement learning activities in an efficient manner.

INTRODUCTION TO COMMUNICATION TECHNOLOGY

Suggested Learning Objectives

Upon completion of the introduction to communication technology unit, students will be able to:

A. Define and properly use common communication technology terminology like transmitter, link, receiver, symbol, format, encode, decode, audience, and media.

B. Describe and apply a communication model featuring a sender, encoding, transmitting, link, receiving, decoding, receiver, and a feedback loop to common graphic and electronic communication systems. LA4

C. Categorize common communication technologies like radio, television, drafting, photography as graphic or electronic systems.

D. Categorize common communication technologies like newspapers, telephones, magazines, and citizen band radios as one-way or two-way communication systems.

E. Discriminate between passive and active forms of communication technology.

F. Identify basic applications for communication technology including recording, educating, entertaining, describing, informing, and persuading.

G. Evaluate the societal and environmental impacts associated with communication technology including the exchange of information between cultures, noise pollution, and utilization of natural resources. SC2

H. Forecast the consequences of poor communication and describe technological strategies for improving communication between people. SC2

I. Select the optimum means of communication for addressing a specific communication problem based on the environment, media, cost, time, and content considerations.

Suggested Learning Experiences

1. Introduce students to the general communication model (i.e., sender, encoding, transmitting, link, receiving, decoding, receiver, and feedback loop). Divide the class into groups of two and have them set back to back. Provide one member of each team a sheet of paper illustrating several graphic configurations (e.g., staked rectangles, squares, triangles). Have one student describe one of the configurations while the other student tries to draw it. When each team has finished, ask them to compare their drawing with the

original. Have students exchange roles and conduct a second round. This time, allow students to provide each other feedback during the communication process. Ask students to evaluate how the game relates to the general communication model, determine where communication broke down, and recommend ways to improve the communication process.

2. Introduce students to a variety of graphic and electronic forms of communication technology. Include things like graphic arts, photography, drafting, radio, television, telephone, and computer technology. Assign each student a topic and ask them to develop a display describing their assigned communication technology topic. Each display should illustrate if the communication technology is graphic or electronic, one-way or two-way, passive or active, and how it fits into the communication model.

3. Discuss how technology is used to solve communication problems. Have students evaluate, select and present the best communication system to address a given communication problem. Possible problems could include things like showing someone how to perform a process, describe an object, and tell a large group of people about an upcoming event. Discuss why given types of communication technology are more appropriate for certain applications than others.

4. Discuss the evolution of communication technology and how it has shaped the way we communicate to one another. Assign small groups of students a time period in history. Have each group research and develop a pictorial timeline illustrating the major developments in communication technology during their assigned time period. When all the groups have finished, link the timelines together. Ask students to evaluate how communication technology has influenced our culture.

Suggested Learning Objectives

Upon completion of the drafting and design unit, students will be able to:

A. Define and properly use common drafting and design **terminology** like orthographic, modeling, oblique, plot, radius, and project. MA6

B. Identify basic **applications** for drafting and design like communicating detailed information, specifying products and structures, illustrating assembly and servicing procedures, and describing electrical and fluid power circuits. MA6

C. Describe the major milestones in the **history** and evolution of drafting and design technology including the development of measuring units, introduction of photochemical reproduction techniques, and integration of computer-aided drafting and design systems. SS2

D. Describe the basic drafting and design **processes** like centering, dimensioning, drawing, designing, reproducing, plotting, digitizing, formatting, presenting, lettering, layering, and reproducing.

E. Describe the basic human, material, natural, informational, financial, and technological **resources** associated with drafting and design processes and enterprises (e.g., paper, specifications, computers).

F. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when around or participating in drafting and designing activities. PH3

G. Discuss the **career** opportunities in design and drafting technology (e.g., architect, CAD system operator, technical illustrator) based on their interests, talents, and career expectations.

H. Describe the societal and environmental **impacts** associated with drafting and design like creating solutions to problems, promoting efficient action, and facilitating artistic expression. SC2

I. Prepare and translate a variety of pictorial drawings that illustrate and specify objects, structures, data sets, systems, and processes. MA6.

J. Prepare and interpret graphs that illustrate and specify trends, facilitate comparisons, and show relationship within a given set of data. MA 7

K. Prepare and translate multiview drawings that illustrate and specify components and assemblies. MA 6

L. Prepare and translate architectural drawings that illustrate, and specify architectural sites, plans, structural details, and utility and climate control systems. MA6

M. Prepare and translate schematic drawings that illustrate and specify electrical and fluid power circuits and components. MA6

N. Prepare and translate maps that illustrate and specify geographic features, distances, locations, and routes. MA6

O. Prepare and translate charts that illustrate and specify organizations and procedures. MA7

P. Use common traditional and computer-aided drafting and design tools to prepare pictorial drawings, architectural drawings, multiview drawings, schematics, charts, graphs, and maps. PH6

Q. Follow common drafting and design conventions when preparing pictorial drawings, architectural drawings, multiview drawings, schematics, charts, graphs, and maps.

R. Select and defend the best drafting or design techniques for illustrating and specifying a given data set, object, procedure, system, or structure. MA6

S. Prepare and translate basic bills of materials, schedules, parts lists, notes, and specifications. LA1

T. Produce three dimensional objects based on two dimensional communication media and prepare two dimensional communication media based on three dimensional objects. MA6

Suggested Learning Experiences

1. Discuss how drafting is used to communicate three dimensional information using two dimensional media. Provide each student a three dimensional mock-up for a simple object. Have each student draft a multiview drawing for their assigned object. When they have finished, have students exchange and use the drawings to make the objects using an easy-to-shape material (e.g., soap, clay, styrofoam). Compare and contrast the mock-ups made from the drawings with the originals. Have students identify discrepancies between mock-ups and trouble shoot the communication process. Ask students to identify the consequences of poor communication (e.g., wasted time, money, and materials) and suggest strategies for ensuring accurate communication (e.g., conventions, standards, proofing, computer-aided design/drafting).
2. Discuss how multiview drawings can be used to describe a product to be manufactured. Have students use traditional or computer-aided drafting tools to design and prepare plans for a simple product (i.e., business card holder, machine part, memo pad holder). Include processes like determining the number of views, assigning dimensions, developing a bill of materials, and providing notes and specifications. Ask students why neatness and accuracy are important when drafting plans for an object.
3. Discuss how architectural drawings are used to describe a structure to be constructed. Have students use traditional or computer-aided drafting tools to design and prepare a site, foundation, and floor plan for a simple structure (e.g., vacation house, storage building, room addition). Include processes like dimension, interior and exterior features, drawing structural details, and providing schedules. Discuss the differences between mechanical and architectural drawings.

4. Introduce students to the concept of geometric modeling. Demonstrate how to create and manipulate geometric models for a product or structure using computer-aided design technology. Have students use a geometric modeling or drafting program to create a skeleton view of an object. Have students rotate, view and print the object from several perspectives. Ask students to describe the implications of being able to manipulate and test a geometric model during the design process.

5. Discuss how line graphs can be used to communicate given types of information graphically. Provide students sales information for fictitious companies. Have students use traditional drawing tools or a business graphics program to create line graphs illustrating the number of products sold each month for one year. Use the graphs to identify sales patterns or trends.

6. Explain how graphs can be used to make comparisons. Provide students quality control information for fictitious companies. Have students use traditional drafting tools or a business graphics program to develop bar graphs illustrating the number of defective products produced each day. Use the graphs to evaluate and identify when quality control efforts need to be stepped up.

7. Discuss how pie graphs help people understand how something is divided into smaller groups. Provide students information regarding how energy is used in the United States. Using traditional drafting tools or a business graphics program, have students make pie graphs illustrating what percentage of our energy resources are used for industrial, transportation, residential, and commercial applications. Use the graphs to evaluate which applications use the most energy.

8. Discuss how charts can be used to illustrate a sequence of operations. Using traditional or computer-aided drafting tools have students develop flow charts illustrating the steps needed to produce or service a simple product. Discuss how flow charts are used to develop and communicate computer programs, production sequences, and trouble shooting procedures.

9. Provide students a table of information describing the cost, specifications, and performance characteristics for automobiles in various categories. Have small groups of students prepare a series of graphs to explain and describe the automobiles in the table. Encourage students to use appropriate graphs to communicate things like number of compact, intermediate, and full size cars; the relationship between engine size and quarter mile speed; and the average gas mileage for cars in each category. Ask students to identify and evaluate solutions to ethical problems caused by manipulating things like scales, dimensions, and symbols when preparing graphs, to visually distort the information being presented.

10. Explain how schematic drawings are used to illustrate and specify electrical and fluid power circuits. Provide students pictorial or physical representations of electrical and/or fluid power circuits. Using traditional or computer-aided drafting tools, have students prepare a schematic for their assigned circuit. Include processes like identifying appropriate symbols for each component and

reconfiguring the circuit. Ask students to assess the usefulness of schematic drawings to manufacture, install, and service electrical and fluid power systems.

11. Discuss how maps are a form of drafting and how they are used to communicate geographic features, locations, distances, and routes. Provide each student a problem statement based on a need to get from one location to another or to describe a geographic region (e.g., community, neighborhood, facility). Using traditional or computer-aided drafting/design tools, have students draw maps for their assigned problems. Include processes like using scales, selecting symbols, and/or illustrating topographical features. Ask students to exchange their maps and evaluate their ability to address the assigned problem.

12. Discuss the milestones in the history and evolution of drafting and design technology. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

13. Discuss the career opportunities in drafting and design technology. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to design and drafting technology. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

Suggested Learning Objectives

Upon completion of the photography unit, students will be able to:

A. Define and properly use common photography **terminology** like composition, exposure, projection, aperture, depth of field, and telephoto.

B. Identify basic **applications** for photography technology including complementing and enhancing written messages, keeping and producing records, researching life and motion, advertising products and services, and facilitating artistic expression.

C. Describe the societal and environmental **impacts** associated with photography technology including the utilization of precious metals, disposal of hazardous chemicals, and recording of historical events. SC2

D. Describe basic **processes** like preparing, composing, lighting, exposing, developing, stopping, fixing, washing, enlarging, mounting, sequencing, projecting, and presenting. SC1

E. Describe the natural, human, financial, informational, material, and technological **resources** associated with photographic processes and enterprises (e.g., silver, light, subjects).

F. Describe the major milestones in the **history** and evolution of photography including the invention of camera obscurity, the introduction of Kodak and Polaroid cameras, and the development of hologram technology. SS2

G. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when working with photographic equipment, materials, and chemicals. PH3

H. Identify and evaluate **career** opportunities relating to photography (e.g., photographer, photo lab technician, photo journalist) based on their interests, talents, and career expectations.

I. Describe the equipment, chemicals, and processes used to develop light sensitive materials including photographic paper, as well as black and white, color, and slide film. SC4

J. Determine the appropriate exposure for a given subject based on lighting, motion, depth of field, color, and film speed considerations.

K. Apply basic mathematical concepts to do things like time photographic processes and determine appropriate shutter speed and aperture settings. MA2

L. Explain how scientific concepts like reflection, refraction, and focal plane apply to cameras and photographing images. SC1

M. Using common photographic equipment, materials and services, perform basic photographic processes like lighting subjects, photographing subjects, developing film, and projecting images.

N. Evaluate and compose photographs using the basic rules of composition such as the rule of thirds, framing subjects, screening the background, and using contrast. FA1

O. Evaluate photographic presentations based on composition, exposure, content, sequencing, and audience considerations.

P. Determine the best photographic equipment and materials for preparing and presenting a media presentation based on production, audience, content, environment, time, and cost considerations.

Q. Prepare and make a photographic presentation addressing a given communication problem based on audience, content, environment, time, and cost considerations.

R. Forecast how an audience will respond to specific photographs and photographic presentations.

Suggested Learning Experiences

1. Introduce students to the concept of recording images on a light sensitive material. Have students make photograms by placing opaque, transparent, and translucent objects on a sheet of photographic paper and exposing it to light. Develop the photographic paper and discuss how the different objects affected the exposure. Ask students to describe how the ability to use light to record images has influenced our culture.

2. Discuss the basic elements needed to record an image on to a light sensitive material (i.e., light-tight box, film, aperture, shutter, viewfinder, lens). Using simple materials, have each student make a pin hole camera. Use the homemade cameras to photograph a variety of objects. Encourage students to experiment with the amount of time and light used to expose the film. Ask students to identify the basic parts on a variety of cameras.

3. Discuss how photography is used to enhance communication during training, sales, and public relations presentations. Divide the class into small groups and have each group identify and describe a presentation topic. Potential presentations could describe how to boot a diskette in a computer, use a machine in the laboratory or load film into a camera. Ask students to explain how photography can be used to complement and enhance written and verbal communication. Discuss the importance of supporting text with pictures and pictures with text.

4. Explain how photographic presentations have to be planned to achieve communication objectives. Have each group develop a story board describing the sequence of the verbal and visual information needed to address their presentation topic. Each story board should include an introduction, a content presentation, and a list of closing credits. Ask students to describe the difference between taking professional photographs and snap shots. Have students forecast how their photographic presentations will be received by an audience.

5. Explain how to use the basic rules of composition to compose and evaluate photographs, including techniques like the rule of thirds, framing the subject, screen background, adjusting the depth of the field, and using contrast. Ask students to evaluate a variety of photographs and identify examples of good and poor composition. Have students apply the basic rules of composition during subsequent learning activities. Discuss the importance of using good composition to enhance the aesthetic quality of photographs.

6. Show students how to use a simple camera to take photographs. Include processes like loading film, advancing film, adjusting film speed, focusing the camera, setting the exposure, activating the shutter, and rewinding film. Have students use popular photographic equipment to take photographs of a variety of subjects. Ask students to describe how they can use photography to capture and record important moments.

7. Show students various types of cameras and film and discuss their advantages, disadvantages, and applications. Divide the class into small groups and have each group determine the best camera and film to use to solve a given problem. Possible problems could include identifying the heat produced by an object, taking snapshots of family events, recording an indoor event without flash, conducting a presentation to a large group of people, or making a poster size print. Ask students to identify the consequences of selecting the wrong type of film or camera for a professional photography assignment.

8. Explain how professional photographers conduct photo sessions. Discuss how they use graphics, lighting, props, and models to create and compose the subject being photographed. Have students compose and photograph the subjects for each frame of their story board. Ask students to identify and discuss the aesthetic, ethical, and communication considerations that need to be addressed when taking photographs.

9. Explain the importance of controlling and balancing the amount of light and exposure time used to photograph various types of subjects. Using adjustable cameras, have students photograph a variety of stationary and moving objects. Ask students to determine and record the appropriate aperture and shutter speed settings for photographing a moving vehicle, cloud, child, landscape, or one person in a crowd. Have students evaluate photographs based on lighting, motion, and subject considerations.

10. Demonstrate the materials and processes used to develop film. Using laboratory equipment and chemicals, have students develop their film. Include processes like removing film from its canister, preparing the film for development, and developing, stopping, fixing, washing, and drying negatives. Have students explain why it is important to follow established procedures when developing film.

11. Explain how negatives are used to produce prints. Using basic darkroom equipment, have students make prints from their negatives. Include processes like adjusting and focusing an enlarger; cleaning and positioning negatives; making, developing, and analyzing test strips; positioning and exposing photographic paper;

and developing, stopping, fixing, washing, and drying prints. Have students examine the ethical issues related to manipulating photographs to communicate false or biased information.

12. Discuss how photographs are assembled, sequenced, mounted, and displayed for museum, public relations, and trade show presentations. Using colored paper, poster board, spray contact cement, and/or dry transfer paper, have each group create a photographic presentation by selecting, sequencing, and mounting their photographs and captions on a large story board or display. Ask students to identify the advantages and disadvantages of presenting information through photographs and captions.
13. Explain how slides can be used to make presentations. Using a slide projector, screen, and cassette recorder, have each group select and sequence their best slides; record their script and cues on cassette tape; and preview their slide presentation. Discuss the flexibility and communication value of slide presentations. Have students compare and contrast slides with other forms of presentation media (e.g., photographs, films, video tapes).
14. Introduce students to the three basic types of presentations (i.e., person-to-person, small group, large group). Discuss the room, seating, equipment, and format considerations for each type of presentation. Have each group practice, promote, prepare and present their presentations to the class and invited guests. Using a teacher-made evaluation instrument, have each member of the audience evaluate the script, photographs, and presenters. Ask each team what they would change if they had to make their presentation again. Have students describe the consequences of a good presentation in a variety of business and industry contexts.
15. Discuss the milestones in the history and evolution of photography technology. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.
16. Discuss the career opportunities in photography technology. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to photography technology. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

Suggested Learning Objectives

Upon completion of the graphic arts unit, students will be able to:

A. Define and properly use common graphic arts **terminology** like lithography, paste-up, compose, point, fonts and electrostatic typeface.

B. Identify basic **applications** for graphic arts technology including artistic expression, recording information, communicating ideas, disseminating news, and advertising products.

C. Describe the societal and environmental **impacts** associated with graphic arts technology including facilitating communication between people and organizations, utilization of natural resources, visual pollution, and aesthetic expression. SC2

D. Describe the equipment, techniques, and **applications** for common duplication technologies including relief, screen, gravure, planographic, electrostatic, and photographic.

E. Identify basic natural, human, material, financial, technological and information **resources** used in graphic arts enterprises (e.g., paper, graphic designers, duplication equipment).

F. Describe the major milestones in the **history** and evolution of graphic arts technology including the invention of paper and movable type, the introduction of lithography and electrostatic printing processes, and integration of photographic techniques, and the development of electronic typesetting and publishing technologies. SS2

G. Describe basic graphic arts **processes** like typesetting, formatting, composing, illustrating, stripping, photographing, registering, duplicating, binding, and finishing.

H. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when around or participating in graphic arts activities. PH3

I. Identify, describe, and evaluate **career** opportunities in the graphic arts industry (e.g., typesetter, press operator, graphic designer, publisher) based on their interests, talents, and career expectations.

J. Apply basic mathematical concepts to do things like measure copy and materials, as well as estimate production costs. MA1

K. Use basic graphic design techniques to identify, select, combine, refine, and present potential graphic products that address a given communication problem.

L. Evaluate and design graphic products based on the basic rule of composition including balance, unity, rhythm, proportion, and contrast. FA1

M. Determine the best printing technique based on material, quantity, cost, quality, audience, and equipment considerations.

N. Apply the basic communication model to graphic arts media including newspapers, billboards, magazines, and brochures. LA1

O. Forecast the effects of electronic publishing technology on things like employment patterns, printing costs, and product quality. SC2

P. Select the optimum means for communication addressing a specific communication problem based on material, content, audience, dissemination, design, cost, and quality control considerations.

Q. Use common graphic arts tools, materials, equipment, and machines to design and duplicate a simple graphic product that addresses a given communication problem.

R. Use graphic arts techniques to transmit messages accurately and in good taste.

Suggested Learning Experiences

1. Introduce students to a variety of graphic arts enterprises. Discuss the products they produce and how they are organized. Include newspaper companies, book publishers, printing houses, and job shops in your discussion. Divide the class into small groups. Have each group create, name, and organize a graphic arts company by desighing a logo, selecting jobs, and/or completing an organization chart. Ask students to identify and discuss the various roles played by graphic communication companies in our society. Have students discuss the power associated with access to graphic communication technology.
2. Explain how people and organizations use graphic products to communicate messages to an audience. Have each group identify a message that needs to be transmitted to a given audience. Possible messages could center around announcing an upcoming event, promoting an organization, expressing an opinion, describing a program, educating people about a topic, or persuading people to purchase a product. Have students discuss the ethical issues associated with using print media to influence people.
3. Introduce students to the basic types of graphic products used to transmit messages. Include things like newsletters, packaging, T-shirts, brochures, posters, books, and magazines. Explain how the type of graphic produced depends on the message being transmitted. Have each group evaluate and select the best graphic product for transmitting their message based on audience, material, equipment, cost, quality control, and production considerations. Have students identify and discuss the positive and negative effects of using bill boards, junk mail, and newspapers to transmit messages.
4. Introduce students to the concept of composition. Show students how things like color, typeface, contrast, rhythm, balance, proportion, and unit are used to make graphic products functional and attractive. Show students a variety of graphic products and have them identify examples that use formal and informal balance, vertical and horizontal positioning, screen tints, the golden line of

proportion, and/or reverse lettering. Require students to use one or more of the basic composition techniques during the following learning activity. Ask students to identify graphic products that have good and poor composition.

5. Explain how graphic designers create, evaluate, select, and refine designs for graphic products. Using brainstorming techniques, have each group generate a variety of design ideas for their graphic product. Require students to record each idea in the form of a thumbnail sketch. When they have finished, have each group evaluate, select, and combine their best design ideas into one rough layout for their graphic product. Ask students to explain why it is important to accept everyone's ideas during a brainstorming session. Discuss the consequence of a poor design.

6. Discuss how various graphic arts companies gather information and compose messages for graphic products. Have each group gather information about the topic being featured on their graphic product. If appropriate, include elements that address who, what, where, when, how, and why. Use the information gathered to write the messages that will be featured on their graphic product. Require students to develop outlines, write a rough draft, edit the draft, and proofread the final copy. Ask students to explain the importance of truth and accuracy when preparing and presenting information through print media.

7. Discuss how illustrations complement and enhance written messages. Using clip art, photographs, computer generated art, and/or original art, have students illustrate the messages for their graphic products. Discuss the ethical considerations that must be addressed when evaluating, selecting, and using illustrations for graphic products. Have students explain when an illustration is in bad taste.

8. Demonstrate and discuss how designs for graphic products are prepared for duplication. Using traditional or computer-aided graphic arts tools and techniques, have each group prepare a mechanical layout for their graphic product. Include tasks like drafting the layout, cropping and positioning illustrations, composing and positioning copy, and preparing camera ready copy. Ask students to forecast how electronic publishing technology will change how people and organizations communicate.

9. Introduce students to the techniques used to print graphic products. Include relief, electrostatic, photographic, screen, planographic, and gravure techniques in your discussion. Discuss the advantages, disadvantages, and application of each printing process. Have each group evaluate and select the best printing techniques for their graphic product based on material, quality control, cost, equipment, and production considerations. Ask students to determine the best printing technology for a variety of graphic products (e.g., pop cans, movie posters, bill boards, automobile brochures).

10. Introduce students to the concept of an image carrier. Demonstrate how to prepare silk screens, compose type, and/or make offset-lithography plates. Using laboratory tools, equipment, and mate-

rials, have each group prepare an image carrier for reproducing their graphic product. Include processes like mounting screens, preparing and adhering stencils, and exposing and developing plates. Ask students to identify the consequences of not following established procedures when preparing an image carrier.

11. Demonstrate how to use the tools, equipment and/or machines needed to duplicate each group's graphic product. Emphasize the safety considerations associated with operating various types of printing equipment. Using laboratory printing equipment and machines, have each group reproduce their graphic product. Include processes like preparing ink, feeding or registering paper, and operating and cleaning equipment. Have students discuss the impact of automated printing processes and equipment on things like product quality, company profit, and employment patterns.

12. Discuss how graphic products are advertised, sold, and distributed. Have each group develop and implement a simple advertising, sales, and/or distribution strategy for their graphic product. Ask students to forecast how telecommunication technologies like on-line databases, facsimile systems, and telemarketing will affect graphic communication technologies and enterprises in the future.

13. Discuss the milestones in the history and evolution of graphic arts technology. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

14. Discuss the career opportunities in graphic arts. Include occupations at the unskilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have each student gather information and present a short written or verbal report about an occupation related to graphic arts. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask each student to evaluate the career based on their interests, talents, and career expectations.

Suggested Learning Objectives

Upon completion of the computer technology unit, students will be able to:

A. Identify the basic elements required to process information including people, hardware, software, and data.

B. Define and properly use common computer **terminology** like hardware, software, random access memory, read only memory, and microprocessor.

C. Identify basic **applications** for computer technology including creating graphic illustrations, preparing written documents, making mathematical calculations, and storing large amounts of data.

D. Describe the basic computer communication **processes** like entering, storing, modeling, scanning, displaying, searching, sending, copying, manipulating, calculating, initializing, and formatting.

E. Describe the basic human, material, natural, informational, financial, and technological **resources** associated with processing and communicating information with computer technology (e.g., silicon, languages, data).

F. Describe the social and environmental **impacts** associated with processing and communicating information with computer including operator stress, increased productivity, obsolescence, and energy utlization. SC2

G. Identify and evaluate **career** opportunities associated with processing and communicating information with computers (e.g., programmer, computer technician, systems analyst) based on their interests, talents, and career expectations.

H. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when around or participating in computer-related activities.

I. Describe the positive and negative impacts of processing and communication information with computer technology (e.g., job displacement, information overloading, improved efficiency). SC2

J. Identify the major milestones in the **history** and development of computer technology including things like Charles Babbage's Analytical Engine, the ENIAC computer, the development of the integrated circuit and the Crag Super Computer. SS2

K. Explain how the input, processing, memory and output systems of a computer process and store information.

L. Identify and properly use common computer input, processing, output, and storage devices. PH6

M. Use popular computer software and hardware to prepare, edit, and compose a variety of print media including correspondence, charts, graphs, drawings, reports, and newsletters. LA3

N. Describe how computer technology is used to transmit and receive text and graphic information via telecommunication technologies like electronic mail, facsimile, and on-line databases.

O. Use popular computer software and hardware to organize numeric data, perform calculations, and make projections.

P. Distinguish between dedicated and general purpose computers.

Q. Develop a procedure for solving a simple problem with a computer using pseudo code, flow charts or a high level computer language.

R. Write, enter, debug, format, and run a computer program that addresses a simple information processing or communication problem.

S. Select the most appropriate computer software and hardware for a given information processing or communication task.

T. Assess the advantages and disadvantages of using computer technology to perform a given task. SC2

U. Practice the procedures used to maintain and protect computer software and hardware.

V. Integrate the use of computer technology in their academic, avocational and vocational activities.

W. Identify and evaluate solutions for solving the ethical problems associated with using computer technology including privacy, copyrights, and dehumanization. SC2

Suggested Learning Experiences

1. Discuss how computer aided instruction is used to help train personnel in business and industry. Use a variety of tutorial programs to introduce students to the world of computing. Include programs that simulate how a computer works and describe how to use a computer. Ask students to identify the advantages and disadvantages of using computers to facilitate instruction.

2. Introduce students to the three basic elements required to process information (e.g., information, hardware, software). Provide students a mathematical problem involving a list of numbers, a sequential series of steps, and a calculator. In groups of three, have students use calculators to process the information and solve the problem. Discuss the basic elements used to process information and how they apply to a variety of industrial contexts and information technologies. Ask students to identify mistakes that can be made with a calculator or computer. Are there ways to cross-check the mistakes?

3. Discuss how computers are used in industry to solve problems, process information, and create products. Divide the class into two

teams and assign the class a problem to solve (e.g., estimate materials for a project, determine total resistance in a complex circuit, develop a poster promoting an event). Have one team address the problem using traditional methods and allow the other team to use a computer and appropriate software. When both teams have finished the assignment, compare the quality of the results and the time required to solve the problem. Discuss how computer technology can help people and organizations be more efficient and competitive in a technological society.

4. Explain how a computer system is a collection of input, processing, and output devices. Using an appropriate software package, have students make posters identifying various parts of a computer system (e.g., RAM, ROM, CPU, monitor, disk drive, keyboard). Create a block diagram illustrating a computer system by displaying and connecting the posters on a bulletin board. Use the block diagram to discuss how a computer system stores and processes information.

5. Discuss how various information processing tasks require special computer peripherals. Demonstrate how to use a variety of input and output devices (e.g., keyboard, joystick, mouse, printer, plotter, interface, modem). During laboratory activities, have students perform information processing and communication tasks that require using a variety of input and output devices. Discuss the information input and output devices used during laboratory activities and how they transfer to a variety of industrial applications (e.g., scanning forms, digitizing drawings, recording image with video cameras, entering data with bar code readers).

6. Explain and demonstrate how to handle and maintain components like computer diskettes, disk drives, printers, printed circuit boards, and keyboards. During laboratory activities, have students follow the procedures used to care for and protect computer software and hardware products. Ask students to identify the consequences of mistreating computer technology.

7. Discuss how computer technology is used to control machines and process information. Have students identify applications for dedicated computers (e.g., regulating ignition and fuel systems on automobiles, programming microwave ovens, programming video recorders) and general purpose computers (e.g., accounting, record keeping, word processing, designing). Ask students to describe how computer technology is changing the way we live.

8. Introduce students to the concept of a computer program. Discuss how computer programs are basically lists of instructions that the computer uses to process information. Have students break a simple problem down into a series of simple steps and write a computer program using simple English statements. Possible problems could include things like calculating miles per gallon, displaying a hello logo on the screen, and estimating the price of a house based on cost per square foot. Use the computer programs written in English to write real computer programs. Ask students to explain why people need to be able to describe and develop solutions to problems.

9. Discuss how the logic for a computer program can be described graphically. Explain how to use graphic symbols to develop a flow

chart for a simple computer program. During a laboratory activity, have students draw a flow chart for a computer program that displays a question, processes answers, and provides feedback. It should include loops for correct and incorrect responses. Ask students to discuss if the human mind has any capabilities computers do not have. Can a computer detect the ambiguity in the statement "The skies are not cloudy all day."?

10. Explain how the procedure used to solve a problem must be encoded into a language the computer is programmed to understand. Demonstrate how to enter, list, edit, save, load, and run a new program. Introduce students to a variety of basic computer commands (e.g., Print, For/Next, Goto, If/Then). Have each student solve a problem by writing a short computer program. The programs should be easy to use, well documented, and formatted for the computer screen.

11. Introduce students to the concept of word processing. Using a simple program, have each student write, edit, and print a simple memo regarding a class or club activity. Include functions like deleting, moving, finding, replacing, and formatting text. Demonstrate how computer software can be used to check things like grammar, spelling, and style. Discuss how word processing technology is changing written communication in the work place.

12. Demonstrate how to use a popular software package to prepare a graphic product. During a laboratory activity, have students write, edit, compose and print a simple graphic product (e.g., posters, newsletters, flyers, labels, brochures). Discuss the positive and negative impacts of electronic typesetting and publishing on the graphic arts industry.

13. Explain and demonstrate how information can be transmitted and received via telecommunication technologies. Using a modem-equipped computer, have students access an electronic bulletin board, receive messages from others, and enter new messages. If you do not have a modem, consider using an electronic mail or data base program to have students transmit and receive electronic mail from you, their classmates, and students enrolled in their classes.

14. Discuss how graphic products can be composed in one location and transmitted to another for duplication and dissemination. Consider establishing a communication network between two or more schools. During laboratory activities, have students use a modem-equipped computer to exchange newsletters electronically. Discuss how telecommunication technology is changing the graphic arts industry.

15. Assign each student a topic that needs to be researched. Demonstrate how to use a modem-equipped computer to access and use an on-line data base. Have students conduct a search, preview bibliographic citations, and extract documents on their topic from the data base. Discuss the positive and negative impacts of having almost instant access to libraries of information.

16. Discuss how computer technology can be used to process data in a variety of industrial contexts (e.g., research and development, pro-

duction, business). Using an appropriate software package, have students process the numeric information needed to operate a student enterprise or solve a problem (e.g., project a profit margin, determine quality control standards, calculate the efficiency of a device). Ask students to identify the advantages and disadvantages of using computers to perform complex calculations.

17. Discuss the career opportunities in computer technology. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to computer technology. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

18. Discuss the milestones in the history and evolution of computer technology. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

Suggested Learning Objectives

Upon completion of the telecommunications unit, students will be able to:

A. Define and properly use common telecommunications **terminology** like transducer, multiplexing, uplink, geosynchronous orbit, resolution, and frequency. SC1

B. Identify basic **applications** for telecommunications technology including providing entertainment; advertising products and services; and gathering, disseminating, and exchanging information.

C. Describe the basic information, financial, human, natural, and technological **resources** associated with various telecommunication processes and enterprises.

D. Describe basic telecommunication **processes** like modulation, demodulation, amplifying, scanning, switching, networking, transmitting, receiving, recording, and multiplexing. SC1

E. Evaluate the societal and environmental **impacts** associated with telecommunications like land utilization, visual pollution, noise pollution, instant communication throughout the world, crowded radio waves, invasions of privacy, and maintenance of interpersonal relationships with distant friends and relatives. SC2

F. Describe the major milestones in the **history** and evolution of telecommunication technology including the invention of the telegraph, telephone, radio, transistor, and television; the evolution of telephone exchanges from operators to electronic switching; and the development of cable, fiber optics, and satellite communication links. SS2

G. Identify and evaluate **career** opportunities relating to telecommunication technology (e.g., radio announcer, sound engineer, telephone installer) based on their interests, talents, and career expectations.

H. Identify potential **safety** hazards and establish guidelines for safe behavior when using telecommunication technologies. PH3

I. Describe the network of input transducers, transmitters, links, receivers, and input transducers used in a variety of telecommunication technologies including radio, telephone, and television systems.

J. Discriminate between analog and digital signals; describe their advantages, their disadvantages, and how they are used in radio, television and telephone communication systems. SC1

K. Analyze how radio, telephone, and television systems convert and process visual and/or audio information into electrical and/or electromagnetic waves, transmit them over long distances, and convert them back to audio and/or visual information people can understand. SC1

L. Describe the technologies, techniques, and storage mediums used to record and play back audio and/or video information.

M. Select and defend the best telecommunication technology for solving a given communications problem based on content, privacy, financial, and human considerations. SC2

N. Evaluate how technologies like radio, telephone, and television have shaped and are influencing our culture and other cultures.

O. Transmit, record, and receive simple messages using common radio, telephone, and television including tape recorders, video recorders, video cameras, citizen band radios, short wave radios, and telephones. LA4

P. Analyze the role of telecommunication technology in an information era and forecast how a person's ability or inability to obtain or disseminate information will affect their position in society. SC2

Q. Utilize radio, television, and telephone technology in a socially appropriate and productive manor.

Suggested Learning Experiences

1. Discuss the history of electronic communication technology. During a laboratory activity, have students design, build and test a basic telegraph system. Have students encode, transmit, receive, and decode simple messages. Ask students to identify the limitations of the telegraph as a means of communication and how subsequent developments in communication technology address its limitations. Evaluate how early forms of electronic communication technology shaped communication patterns and influenced social behavior.
2. Explain how electricity can be used to transmit and receive verbal information. Using electronic components like speakers, switches, and amplifiers, have students design, build and test an intercommunication system. Discuss the applications and limitations of an intercommunication system as a means of communication.
3. Introduce students to the concept of transmitting information through an optical material in the form of digital pulses of light. Using flashlights as light sources, acrylic plastic rods as fiber optic cables, and wooden disks to adapt the flashlights to the acrylic plastic rods, have pairs of students make a fiber optic communication system. Have one student from each team use their flashlight to transmit a simple message in Morse Code through the acrylic rod. Have the other team members receive, record, decode and respond to the flashed pulses of light at the other end of the fiber optic link. Discuss how digital and fiber optic technology is making telecommunications more efficient by transmitting more information, using less space, and requiring less maintenance.
4. Discuss how the telephone companies are gradually replacing copper telephone cables with fiber optic cables. Using a commercial or constructed fiber optics trainer, have students build and test

an electronic circuit that converts an audio signal to light waves, transmits the lightwaves through a fiber optic cable, and converts the lightwaves back to audio. Ask students to identify the potential implications of replacing copper telephone lines with fiber optic cable. Include topics like new jobs, retraining workers, recycling copper, and better telephone service in the discussion.

5. Explain how laser technology can be used to transmit information from one location to another. Using a laser trainer, have students transmit a recorded message on a laser beam to a receiver. Determine the effects of changing the distance between the laser and the receiver, sprinkling dust across the laser beam, and installing a fiber optic link between the laser and the receiver. Ask students to identify advantages, disadvantages, and possible applications for using laser technology to transmit and receive information.

6. Using several telephones, show students the basic parts of a telephone system. Explain how a telephone system converts sound waves to electrical waves, transmits electrical waves across a link, and converts the electrical waves back to sound waves. Using items like small speakers, telephone cable, and amplifiers, have students build and test a two handset telephone system. Ask students to connect the transmitter speaker from one handset to the amplifier's input terminals and connect the amplifier's output terminals to the receiver speaker on the other handset. Use the same procedure to connect the other speakers and amplifier. Ask students to explain how the telephone system fits in the basic communication model (send, encode, transmit, link, receive, decode, receive, and feedback loop).

7. Introduce students to the concept of switching. Explain how a phone number establishes a circuit between two telephones. Using rotary switches, barrier strips, small amplifiers, and the handsets used in the activity above, have students build and test a switching system that will connect one central handset to a network of handsets. Ask students to describe the impact of a major malfunction in a central switching office on individuals, businesses, and emergency services.

8. Discuss how groups of people in different locations can use teleconferencing technology to communicate with one another at the same time. Using rented or donated teleconferencing equipment, hold a teleconference between two or more schools. Have students discuss the impact of telecommunication technology on society, the school's technology education program, or student organization business. Ask students to identify and evaluate advantages and disadvantages of using teleconferencing. Address issues like industries need to reduce costs, the impersonal nature of communicating over the telephone, and the human need to communicate with people in person.

9. Explain how satellites are used to link distant transmitters and receivers called earth stations. Using commercial or constructed trainers, simulate a satellite communication system using light wave transmitters and receivers. To construct the simulation, use a light wave transmitter to represent a local earth station, a light wave

receiver wired to a light wave transmitter to represent a satellite, and a light wave receiver to represent a distant earth station. Align the components and transmit an audio signal through the simulated local earth station (transmitter), through the satellite (receiver/transmitter), and to the distant earth station (receiver). Forecast the implications of being able to transmit and receive information throughout the world almost instantaneously via satellite.

10. Explain how some satellites act like mirrors in space that reflect radio signals back to earth. Using a laser trainer, have students transmit a recorded message to a receiver by reflecting the beam off a mirror. Ask students to identify the role being played by the laser, mirror, and receiver in the simulation. Discuss how information is transmitted and received via satellite technology.
11. Using a wireless microphone and a portable radio, introduce students to the basic parts of a radio communication system. Explain how radio systems convert sound waves to electrical waves, transmit electromagnetic waves, receive electromagnet waves, and convert electrical waves back to sound waves. Using commercial or constructed kits, have students build and test simple AM or FM radio receivers and/or transmitters. Ask students to evaluate the role radio plays in their lives.
12. Discuss how various types of two-way radios are used for entertainment, business, and emergency applications. Using citizen band or ham radio equipment, have students transmit and receive information from other radio operators. Have students explain why everyone should follow the rules of appropriate conduct when using a two-way radio. Ask students to describe the role of two-way radio in the event of a major disaster and/or phone system failure.
13. Using a video camera/microphone and television, introduce students to the basic parts of a television communication system. Explain how a television system converts light and sound waves to electrical waves, transmits electromagnetic or electrical waves across a link, receives electromagnetic or electrical waves, and converts electrical waves back to light and sound waves. Using a video camera, recorder, and monitor, have small groups of students design, record, and broadcast a simple message using television technology. Ask students to evaluate the role television plays in their lives.
14. Explain how radio frequencies are regulated and utilized for various communication applications. Using a multiband radio, have students monitor a wide range of radio frequencies including those used for police, business, weather, marine, aviation, entertainment and personal applications. Have students compare and contrast the communication techniques used on each frequency band. Have students explain why radio frequencies have to be regulated, why given frequency bands are used for specific applications, and what would happen if anyone could use any frequency.
15. Discuss the advantages and disadvantages of various telecommunications technologies including radio, television and telephone systems. Ask small groups of students to select and defend the best

telecommunication technology for addressing a given problem. Possible problems could feature things like advertising a specific product or service, facilitating communications in the event of a natural disaster, and/or providing educational opportunities to people in a remote and underdeveloped area. Have students evaluate the importance of having access to communication technology at the individual, national and international level.

16. Discuss the various types of businesses associated with the telecommunications industry. Conduct a field trip to or invite a guest speaker from a local radio station, television station, or telephone switching office. Have students ask the industry representative questions about the career opportunities, technologies, services, management techniques, and marketing strategies associated with their business.

17. Discuss the milestones in the history and evolution of telecommunication technology. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

18. Discuss the career opportunities in telecommunication technology. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to telecommunication technology. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

Addresses

The following list of addresses is provided for teachers desiring additional information:

Illinois Vocational Curriculum Center (IVCC)
Sangamon State University F-2
Springfield, IL 62708
800/252-8533

American Vocational Association (AVA)
828 South 2nd Street
Room 403
Springfield, IL 62704
217/433-0815

Curriculum Publications Clearinghouse
Western Illinois University
Horrabin Hall 46
Macomb, IL 61455
800/322-3905

Center for Implementing Technology Education
Department of Industry & Technology
Ball State University
Muncie, IN 47306

Technology Student Association (TSA)
University of Illinois
Department of Vocational & Technical Education
1310 S. Sixth Street
Champaign, IL 61820

Illinois Vocational Association (IVA)
44 Emporia Avenue
Springfield, IL 62702

American Technology Student Association (ATSA)
1908 Association Drive
Reston, VA 22091
703/860-9000

International Technology Education Association (ITEA)
1914 Association Drive
Reston, VA 22091

Illinois Industrial Technology Education Association (IITEA)
44 Emporia Avenue
Springfield, IL 62702

Department of Adult, Vocational and Technical Education
Program Improvement Section
100 North First Street
Springfield, IL 62777

Carol Henry
Mix Coordinator
Gregg Division
McGraw Hill Book Company
New York, NY 10020
(314) 256-2222
The Technology Link

Software

The following partial list of software is offered to help teachers identify programs having potential for application in technology courses:

VERSACAD
Versacad Corporation
7372 Prince Drive
Huntington Beach, CA 92647

IMAGINATOR 3D
10442 Brackenwood Lane N.E.
Bainbridge Island, WA 98110

ADVERTISING: HOW IT AFFECTS YOU
Microcomputer Educational Programs
157 S. Kalamazoo Mall
Suite 250
Kalamazoo, MI 49007

USING THE COMPUTER: APPLICATIONS
Society for Visual Education
1345 Diversey Parkway
Chicago, IL 60614

SURVEYS UNLIMITED
Mindscape Inc.
3444 Dundee Road
North Brook, IL 60062

SURVIVAL MATH
THE PROFESSIONAL SIGN MAKER
Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570

FANTAVISION
THE PRINT SHOP
DAZZLE DRAW

BANK STREET WRITER
BANK STREET FILER
Broderbund Software
17 Paul Drive
San Rafael, CA 94903

CADDRAW
Kitchen Sink Software
903 Knebworth Ct.
Westerville, OH 43081

NEWSROOM
SPRINGBOARD PUBLISHER
GRAPHICS EXPANDER
CERTIFICATE MAKER
Springboard Software, Inc.
7807 Greekridge Circle
Minneapolis, MN 55438

FONTRIX
Data Transforms, Inc.
616 Washington Street
Denver, CO 80203

QUICK DRAFT
Interactive Microware, Inc.
P. O. Box 139
State College, PA 16804

DESIGN-A-ROOM II
Computer Aided Instruction
Systems
Box 177
Holly, MI 48442

HI-RES ARCHITECTURAL DESIGN
ARCHITECTURAL DESIGN, PROFESSIONAL VERSION
Avant-Garde Creations
Eugene, OR 97403

PUBLISH-IT
DESIGN YOUR OWN HOME
POINTE CAD
DISCOVER CAD
Hearlihy & Co.
714 W. Columbia Street
Springfield, OH 45501

MICROCOMPUTER APPLICATIONS IN
VOCATIONAL ED.: TRADES &
INDUSTRY
Illinois State Board of Ed.
Springfield, IL 62777

CAR BUILDER
Weekly Reader Family Software
Xerox Education Publications
245 Long Hill Road
Middletown, CT 06457

MICRO MESSENGER
K-12 Micro Media Publishing
P. O. Box 17
Valley Cottage, NY 10989

CUBE BUILDER
Human Relations Media
175 Tompkins Avenue
Pleasantville, NY 10570-9973

AUTOSKETCH
AUTOCAD
Autodesk, Inc.
2320 Marinship Way
Sausalito, CA 94965

THE GRAPHICS DEPARTMENT
Sensible Software, Inc.
210 S. Woodward, Suite 229
DC Birmingham, MI 48011

Books

The following textbooks will contain information that will help teachers prepare to teach technology courses:

Bame, E. A., & Cummings, P. (2nd. ed.). (1980). *Exploring technology.* Worcester: Davis.

Broekhuizen, R. J. (1988). *Graphic communications.* Mission Hills: Glenco.

Deane, Q. (Ed.). (1982). *How it works.* New York: GrenwichHouse.

Dennis, E. A. (1985). *Applied photography.* Albany: Delmar.

DuVall, J. B., Berger, E. G., Maughan, G. R., Jr., & DeVore, P. W. (Ed.). (1981). *Getting the message.* Worcester: Davis.

Fales, J. F., Kuetemeyer, V. F., Brusic, S. K. (1988). *Technology: Today and tomorrow.* Mission Hills, CA: Glencoe.

Feldman, A., & Gunston, B. (1980). *Technology at work.* New York: Facts on File.

Goetsch, D. L., & Nelson, J. A. (1987). *Technology and you.* Albany: Delmar.

Hacker, M., & Barden, R. A. (1989). *Communication technology.* Albany: Delmar.

Hacker, M., & Barden, R. A. (1988). *Living with technology.* Albany: Delmar.

Hacker, M., & Barden, R. A. (1987). *Technology in your world.* Albany: Delmar.

Harms, H. (Ed.). (1988). *Communication technology activities.* Albany: Delmar

Harpur. P. (Ed.). (1982). *The timetable of technology.* New York: Hearst.

Jollands, D. (Gen. ed.). (1984). *Language and communication.* New York: Arco.

Jollands, D. (Gen. ed.). (1984). *Measuring and computing.* New York: Arco.

Jollands, D. (Gen. ed.). (1984). *Sight, light and color.* New York: Arco.

Jones, R. E., & Robb, J. L. (1986). *Discovering technology communication.* Orlando: Harcourt Brace Jovanovich.

Kenny, M. (1982). *Presenting yourself.* New York: John Wiley & Sons.

Minton, G. D., & Minton, B. K. (1987). *Teaching technology to children.* Worcester: Davis.

Seymour, R. D., Ritz, J. M., & Cloghessy, F. A. (1987). *Exploring communications.* South Holland: Goodheart-Willcox.

Tatchell, J. & Cutler, N. (1983). *Practical things to do with a microcomputer.* Tulsa: EDC.

Taylor, P. (1982). *The kids' whole future catalog.* New York: Random House.

Todd, R., McCrory, D., & Todd, K. (1985). *Understanding and using technology.* Worcester: Davis.

Walker, J. R. (1986). *Graphic arts fundamentals.* South Holland: Goodheart Willcox.

Walker, R. J., & Walker, R. E. (1987). *Exploring Photography.* South Holland: Goodheart Willcox.

Williams, C. F., Badrkhan, K. S., & Daggett, W. R. (1985). *Technology for tomorrow.* Cincinnati: South Western.

Williams, . F., Badrkhan, K. S., & Daggett, W. R. (1985). *Technology at work.* Cincinnati: South Western.

Manuals

Manuals available from the Curriculum Publications Clearinghouse, Western Illinois University, Horrabin Hall 46, Macomb, IL 61455, 800/322-3905:

- Strategies for Problem Solving
- Transition Training: Manual for Personal Growth, Development and Self-Improvement

- The Vocational Ethics Manual
- Generalizable Communications Skills Assessment: User Manual
- Generalizable Communications Skills Assessment: Resource Directory
- Generalizable Interpersonal Skills Assessment: User Manual
- Generalizable Interpersonal Skills Assessment: Resource Directory
- Generalizable Mathematics Skills Assessment: User Manual
- Generalizable Mathematics Skills Assessment: Resource Directory
- Generalizable Reasoning Skills: User Manual
- Generalizable Reasoning Skills: Resource Directory

Energy Utilization Technology Curriculum Guide

ENERGY UTILIZATION TECHNOLOGY

Course Rationale

Since the oil embargo in the early 70's, energy has become a major concern to our nation. Over the past two decades our society has dealt with gas shortages, numerous conservation programs, unstable fuel prices, depleting world finite resources, and an increase demand for energy. We live in a society that is dependent on various modes of transportation, automated production processes, sophisticated communication systems, and time-saving devices, all of which use larger amounts of energy. As our society becomes more energy conscious, the move toward alternative energy sources and conservation techniques have become more apparent.

The demand for more energy has created a need to educate our citizens about the reality of the energy situation. In doing so, persons who become involved in learning about traditional fossil fuels, conservation techniques, and alternative energy sources can develop a better understanding of the applications and their impacts on society.

It will be up to today's students to make the decisions on how energy will be utilized in the future. It is education's responsibility to provide students the knowledge to make rational and informed decisions concerning energy. A course in Energy Utilization Technology can provide a student with an education background and the understanding needed to become an informed citizen.

Course Mission

The purpose of the Energy Utilization Technology course is to orient students to the basic resources, technical processes, industrial applications, and technological impacts related to energy conversion and transmission, fossil fuels, energy conservation, solar power, and alternative energy systems. The course will help students to:

- use and understand the verbal and symbolic language used to describe energy systems and phenomena;
- develop and present creative solutions to present and future energy problems;
- identify and investigate potential career opportunities in the area of energy;
- understand the evolution of energy technology and its influence on our culture; and
- safely use common tools, materials and processes to design, build, and test energy systems.

Course Description

The Energy Utilization Technology course includes units on energy conversion and transmission, fossil fuels and energy conservation, solar power, and alternative energy systems. Each unit will involve students in a wide range of activities and experiences. Student learning experiences will include things like testing mechanical, electrical, and fluid power systems; conducting an energy audit; building solar collectors; and constructing a wind generator.

Course Outline

In the spirit of orientation, students should be introduced to a wide range of fossil fuels, conservation techniques, and alternative energy technologies. The following course outline lists the recommended units for either a nine or an eighteen week format. Potential lesson topics are provided under each unit title. Each lesson should embrace as many of the unit objectives as possible. In a nine week format, an emphasis should be placed on the terminology, resources, processes, applications, impacts, careers and safety concepts that relate to the lesson topic.

Sample Energy Utilization Technology Course Outline

I. Introduction to Energy Utilization Technology

II. Energy Conversion and Transmission
   A. Energy conversion
   B. Mechanical systems
   C. Electrical systems
   D. Fluid Power systems

III. Fossil Fuels and Energy Conversion
   A. Using fossil fuels to generate electricity
   B. Conducting energy audits
   C. Implementing energy conservation strategies

IV. Alternative Energy Systems
   A. Wind
   B. Geothermal
   C. Biomass
   D. Hydroelectric (e.g., tide, wave, river current, ocean current)
   E. Nuclear

V. Solar
   A. Passive solar (e.g., direct and indirect gain)
   B. Active solar (e.g., hydraulic and pneumatic)
   C. Photovoltaic
   D. Solar farms
   E. Solar central receivers

Adapting the Energy Utilization Technology Course Outline to Nine or Eighteen Week Formats

Hands-on learning activities are one of the most powerful ways of helping students learn about technology. Unfortunately, they are very time consuming. The following strategies can be employed to use available laboratory time more efficiently without sacrificing important unit objectives:

- Divide the class into small groups and assign each group a different learning activity related to the lesson topic. When each group has finished their assigned activities, have students present their experiences to the rest of the class. For example, during the alternative energy unit, have each group develop and present an alternative energy system.
- Avoid assigning complex laboratory activities when simpler activities will enable students to experience important concepts and achieve the desired objectives. For example, during the solar energy unit, have students design, build, and test solar collectors made of shoe boxes instead of industrial grade materials.
- Prepare work stations that organize the tools and materials needed to conduct laboratory activities prior to class. For example, during the energy conversion and transmission unit, develop kits for electrical or fluid power circuits that students will build and test.
- Have students experience a wide range of concepts through one or two robust learning activities. For example, during the solar unit, have students make a solar energy system (i.e., collection, conversion, storage, distribution, and control) and transfer it to passive, active, photovoltaic, solar central receiver, and solar farm systems.

During an eighteen week format, students can engage in more complex learning activities and experience given topics in greater depth. In addition, there is an opportunity to provide a wider range of learning experiences. The study of technology allows for an infinite number of learning experiences. Therefore, it is important to select and implement learning activities in an efficient manner.

INTRODUCTION TO ENERGY UTILIZATION TECHNOLOGY

Suggested Learning Objectives

Upon completion of the introduction to energy utilization technology unit, students will be able to:

A. Define and properly use common energy terminology like potential energy, kinetic energy, renewable, and entropy. SC1

B. Categorize energy resources as chemical, thermal, electrical, nuclear, or radiant forms of energy. SC1

C. Categorize energy resources like solar, geothermal, petroleum, and biomass as renewable, nonrenewable, and inexhaustible energy resources. SC1

D. Identify the three basic types of fossil fuels (i.e., coal, petroleum, natural gas). SC1

E. Identify examples of alternate energy resources including wind, hydroelectric, and solar energy. SC1

F. Describe how the basic laws of nature like the law of conservation of matter, the first law of thermodynamics (conservation of energy), the second law of thermodynamics (energy degradation) and Newton's laws of motion govern the utilization energy. SC1

G. Identify basic transportation, residential, commercial, and industrial applications for fossil fuel and alternate energy resources. SC1

H. Describe how supply and demand affect the cost and utilization of fossil fuel and alternate energy resources.

I. Define and distinguish between potential and kinetic forms of energy. SC1

J. Measure phenomena like force, work, heat, energy, power, pressure and torque using appropriate measuring tools and units. SC4

K. Forecast the consequence of being dependent on nonrenewable resources and develop scenarios describing the role of energy conservation and alternate energy in reducing our dependence on fossil fuels. SC2

Suggested Learning Experiences

1. Introduce students to a variety of fossil fuels and alternative energy resources. Include topics like geothermal, hydroelectric, coal, nuclear, and wind energy. Assign each student a topic and ask them to develop a display describing the energy resource. Each display should identify if the energy resource is a potential or kinetic energy; a renewable, nonrenewable or inexhaustible energy resource; or a mechanical, chemical, thermal, radiant or nuclear form of energy.

2. Explain how to use the tools, techniques, and units used to measure things like force, work, heat, energy, power, pressure and torque. Using tools like spring scales, thermometers, and VOM meters, have students measure things like work performed by a lever, heat produced by a candle in BTU's, and energy used to illuminate a light bulb.

ENERGY
CONVERSION
AND
TRANSMISSION
SYSTEMS

Suggested Learning Objectives

Upon completion of the energy conversion and transmission unit, students will be able to:

A. Define and properly use common alternate energy **terminology** like transducer, pneumatics, efficiency, thermosiphoning, and mechanical advantage. SC1

B. Identify basic **applications** for energy conversion and transmission systems including providing light, generating electricity, measuring heat, creating motion, and applying forces. SC1

C. Describe the basic human, material, natural, informational, financial, and technological **resources** associated with energy conversion and transmission systems (e.g., conductors, technicians, primary energy resources).

D. Describe basic energy conversion and transmission **processes** like pumping, conducting, regulating, converting, controlling, and grounding.

E. Describe the social and environmental **impacts** associated with energy conversion and transmission including using valuable raw materials, improving efficiency, visual pollution, and energy utilization. SC2

F. Identify and evaluate **career** opportunities associated with energy conversion and transmission (e.g., mechanical engineer, scientist, fluid power technician) based on their interests, talents, and career expectations.

G. Describe the major milestones in the **history** and evolution of energy conversion and transmission technology including the establishment of vacuum as a product of atmospheric pressure by Blaise Pascal, the inventions of the first storage battery by Allesandro Volta, the invention of the light bulb by Thomas Edison, and the discovery of the photovoltaic effect. SS2

H. Identify potential **safety** hazards and establish guidelines for safe behavior when working with electrical, mechanical, thermal, and fluid power systems. PH3

I. Design, build, and test electrical, mechanical, thermal, and fluid power systems that address an energy conversion or transmission problem. SC4

J. Analyze technological systems and identify their mechanical, electrical, fluid power, and thermal subsystems. SC1

K. Determine the basic energy transducers, control devices, and conductor paths used in simple electrical and fluid power systems.

L. Determine the simple machines used in simple mechanical systems. SC1

M. Determine the heat sources, thermal conductors, insulators, and heat skins used in simple thermal systems. SC1

N. Measure phenomena like force, work, heat, energy, power, pressure and torque using appropriate measuring tools and units. SC4

O. Determine unknown quantities like voltage, pressure, flow rate, or current in an electrical and fluid power system based on two known quantities. SC4

P. Design, build, and test energy systems that convert one form of energy to another (e.g., chemical to electrical, chemical to thermal, electrical to mechanical, linear mechanical to rotary mechanical). SC1

Q. Determine the input and output forms of energy associated with energy conversion devices like batteries, bulbs, motors, generators, thermocouples, and photovoltaics. SC1

R. Select and defend the best energy conversion and transmission system for a given problem based on societal, monetary, environmental, and safety considerations. SC2

S. Forecast the potential effects of innovative energy conversion and transportation technologies on consumer products, industrial processes, and energy utilization. SC2

Suggested Learning Experiences

1. Introduce students to the basic forms of energy, chemical, electrical, mechanical, thermal, and radiant. Explain how energy is converted from one form to another. Have students make and/or test energy conversion devices like batteries, photovoltaics, generators, pumps, Hero engines, and thermocouples. Ask students to identify the form of input and output energy for each device. Discuss current and potential applications for each energy conversion device.
2. Compare and contrast how electrical, mechanical, thermal, and fluid power systems are used to perform work. Have students use commercial or constructed trainers to build working electrical, mechanical, thermal, and fluid power systems that perform a given task. Ask students to use appropriate tools to measure things like force, work, heat, energy, power, pressure and/or torque.
3. Introduce students to a variety of energy transducers, control devices, conductor paths, and output transducers used in electrical systems. Using a variety of components, have small groups of students build, test and evaluate electrical circuits that address assigned problems. Possible problems could include things like activating a motor at a given temperature, sounding an alarm when a magnetic connection is broken, being able to turn on or off a light from two

locations, requiring both hands to be in defined locations before a motor will work, and using resistance (photocell) to measure light.

4. Introduce students to the various simple machines used in mechanical systems. Using a variety of commercial or fabricated components like cams, gears, levers, linkages, pulleys, sprockets, chains, and racks, have students build, test and evaluate mechanical systems that address assigned problems. The problems could be expressed in an industrial context, featuring challenges like converting a linear motion to a rotary motion, converting rotary motion to a linear motion, converting a clockwise motion to a counterclockwise motion, and enlarging a given motion by a factor of four.

5. Introduce students to the pressure sources, control devices, conductors, and actuators used in hydraulic and pneumatic fluid power systems. Using commercial fluid power components or things like medical syringes, windshield washer pumps, aquarium valves, and plastic hose, have students build and test fluid power systems that address assigned problems. Possible problems could include things like lifting a given object with a cylinder, clamping an object in a fixture, activating a lever with a cylinder, activating several cylinders in a given sequence, and pumping a fluid to several containers at various rates simultaneously.

6. Introduce students to the heat sources, thermal conductors, thermal insulators, and heat sinks used in thermal energy systems. Using a variety of materials like copper tubing, fiberglass insulation, sheet metal, sterno, and electric heat elements, have groups of students design, build and test thermal systems that address assigned problems. Potential problems could include things like heating a container of water, heating air within an enclosure, cooling the air within an enclosure, transmitting heat from one fluid to another, and storing heat in a thermal mass. Ask students to identify the thermal techniques and systems used in their homes.

7. Explain how many technological systems can be more easily understood by breaking them down into their smaller subsystems. Ask students to identify the major mechanical, electrical, fluid power, and thermal systems on an automobile. Have them categorize things like head lamps, the radiator, steering linkage, and water pump as levers, conductors, pressure sources, actuators, output transducers, control devices, etc. Have students use the same techniques to analyze other technological systems like an industrial robot, internal combustion engine, or a milling machine.

8. Introduce students to the various techniques used to transmit energy from one location to another. Provide groups of students proolem statements that can be addressed with an electrical, mechanical, thermal, and/or fluid power system. Using commercial and/or fabricated components, have each group design, build, and test a system that addresses their problem. Have students present and defend their solutions based on societal, monetary, environmental, and safety considerations.

9. Discuss career opportunities in energy conversion and transmission systems. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to energy conversion and transmission systems. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.
10. Discuss the milestones in the history and evolution of energy conversion and transmission systems. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

FOSSIL FUELS AND ENERGY CONSERVATION

Suggested Learning Objectives

Upon completion of the fossil fuel and energy conservation unit, students will be able to:

A. Define and properly use common fossil fuel and energy conservation **terminology** like bituminous, distillation, reserves, infiltration, insulation, and fractionation. SC1

B. Describe the basic fossil fuel **processes** like surveying, drilling, refining, piping, mining, burning, and transporting.

C. Describe basic energy conservation **processes** like auditing, insulating, conserving, monitoring, and adjusting.

D. Describe the basic human, material, natural, informational, financial, and technological **resources** associated with fossil fuels and energy conservation (e.g., auditors, mining equipment, geological surveys, and insulating materials).

E. Discuss the major milestones in the **history** and evolution of fossil fuels and energy conservation including the discovery of oil fields in Pennsylvania, Texas and Alaska, the development of continuous mining techniques, the 1973 oil embargo, and the introduction of fluidized-bed combustion. SS2

F. Identify and evaluate **career** opportunities associated with fossil fuels and energy conservation (e.g., energy auditor, coal miner, insulation contractor, geologist) based on their interests, talents, and career expectations.

G. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when using fossil fuels and participating in energy conservation activities. PH3

H. Identify basic **applications** for fossil fuel energy resources like heating living space, generating electricity, powering vehicles, fueling industrial equipment, and manufacturing pharmaceuticals and synthetic materials. SC1

I. Describe the environmental and societal **impacts** associated with obtaining, refining, transporting, and burning fossil fuels including acid rain, air pollution, land disruption, oil spills, mining accidents, and pneumoconiosis (black lung disease). SC2

J. Forecast the consequences of America's dependence on fossil fuels and the potential benefits of energy conservation movements. SC2

K. Identify the common energy products produced from fossil fuel energy resources including coal, natural gas, gasoline, lubricants, kerosene, butane, propane, and diesel fuel.

L. Describe the basic techniques used to locate, obtain, refine, and utilize fossil fuels like magnetic and seismic surveying, offshore oil drilling, longwall coal mining, strip mining, and fluidized-bed coal combustion. SC4

M. Describe how science concepts like conduction, radiation, and convection apply to energy conservation, techniques and technologies. SC1

N. Conduct a basic energy audit to identify opportunities to conserve energy by measuring insulation, identifying infiltration points, and assessing life style. SC4

O. Develop, implement and evaluate a plan to reduce energy waste and promote energy conservation.

P. Apply basic mathematical concepts to do things like calculate the BTUH load of a structure, compute the efficiency of an electrical device, and figure the number of kilowatt hours of electricity used by a household. MA1

Q. Evaluate the effectiveness of various energy conservation techniques based on cost, pay back and life style considerations.

R. Demonstrate energy consciousness by integrating energy conservation into the students' lifestyle and purchasing energy efficient consumer goods and services.

S. Evaluate appliances based on cost, specifications, and energy efficiency ratings.

Suggested Learning Experiences

1. Explain how energy audits are used to evaluate structures for energy efficiency and to identify opportunities to conserve energy. Provide students an energy audit check list and have them conduct an energy audit of their homes. Include things like monitoring electricity utilization, measuring attic insulation, inspecting thermostat settings, and checking windows, doors, and receptacles for air infiltration. Have each student use their data to formulate and prioritize a list of energy conservation recommendations for their parents to consider.

2. Explain how aerodynamics and payload affect the energy efficiency of land transportation vehicles. Using model CO2 cars, a timer, a starting system, and a track, have small groups of students modify and test their cars to determine the effects of added weight and aerodynamic obstructions on the car's elapse time. Ask students to identify trends in automobile and truck designs that improve energy efficiency.

3. Discuss the variables that affect an automobile's performance and fuel efficiency. Using a simple check list, have students evaluate their family automobile for energy efficiency. Include things like monitoring gas mileage, keeping a log, inspecting maintenance records, checking tire inflation, and reducing excess weight in the trunk. Have them use the data to formulate and prioritize a list of energy conservation recommendations for parents to consider.

4. Discuss how people waste energy every day by leaving lights on, letting the water run, and not adjusting their thermostat at night. Ask students to identify other bad habits that waste energy. Have students plan and implement an energy conservation campaign at home with slogans, signs, posters, and fliers. Ask students to monitor the amount of energy used by their family before, during, and after their energy conservation campaign. Use the data to evaluate effects of the campaign on their family's energy utilization behavior. Ask students why it is important for their generation to conserve energy.

5. Explain the role of fossil fuels as energy resources for generating electricity. Using a popular computer program, have teams of students run a simulated power plant. Include tasks like monitoring systems, addressing breakdowns, and meeting the demands for electrical energy. Have students evaluate the cost, pollution and safety considerations associated with using fossil fuels to generate electricity.

6. Discuss the role of the boiler, turbine, generator, distribution grid, and consumer in the energy conversion process. Have groups of students build and test model power plants. Each model will need a dry cell battery to represent a boiler, two hobby motors linked together to represent the turbine and generator, and several low voltage light bulbs to represent utility company customers. The battery will power the first motor, the first motor will drive the second motor, and the second motor will generate electricity needed to illuminate the light bulbs. Have each group determine their power plant's efficiency by dividing the power calculated between the second motor and the bulbs by the power calculated between the battery and the first motor and multiplying the total by 100. Discuss how much energy is lost in the energy conversion and distribution process. Ask students to identify the advantages and disadvantages of having centralized utility companies.

7. Discuss how electricity is distributed to communities from several power plants by means of a distribution grid. Using the model power plants made during the activity above, have students create a model distribution grid featuring several power plants and network of customers. Determine the energy supply and demand relationship between the utility and its customers by adding additional consumers (bulbs) to the grid, disconnecting power plants (simulators) from the grid, and disconnect consumers (bulbs) from the grid. Ask students to explain why some utility companies promote energy conservation during the summer, provide lower rates after peak hours, do not want to build new power plants, and how energy conservation can affect the cost of electricity.

8. Introduce students to the concept of diminishing returns and discuss how it applies to energy conservation. Explain how to calculate the BTUH load for a small structure and determine the cost of heating the structure. Have students determine the cost-effectiveness of adding additional insulation, installing storm windows, and/or caulking seams by selecting improvements, recalculating the BTUH load, and refiguring the cost of heating the structure. Have students compare the money saved by making improvements to the cost of the improvements. Ask students to identify the most cost-effective energy conservation improvements.

9. Demonstrate how heat escapes from a structure by means of conduction, radiation, and convection. Have students build a cardboard model of a house. Using a budget, have students purchase and install things like rigid insulation, fiberglass insulation, double glazing, and heat mirror to insulate their structure and reduce heat loss. Using a container of hot water as a heat source, monitor the interior and exterior temperature of the enclosure for a given period of time. Use the data collected to determine the number of BTU's lost per hour. Calculate the efficiency of structure insulation by dividing the number of BTU's lost by the cost of the insulation. Ask students to identify the most cost-effective insulation materials and strategies.
10. Discuss sources of acid rain, how it is produced, and the impact it has on the environment. Using several small potted plants, determine the impact of acid rain in plant life by watering and spraying half the plants with pure water and the other half with water with a high PH level. Have students evaluate and defend a series of ethical and international issues surrounding acid rain.
11. Discuss the milestones in the history and evolution of fossil fuels and energy conservation systems. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.
12. Discuss the career opportunities in fossil fuels and energy conservation systems. Include occupations at the non-skilled, semi-skilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to fossil fuels and energy conservation systems. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

ALTERNATE ENERGY SYSTEMS

Suggested Learning Objectives

Upon completion of the alternate energy unit, students will be able to:

A. Define and properly use common alternate energy **terminology** like turbine, inverter, geothermal fracturing, vertical axis, pyrolysis, and anaerobic. SC1

B. Describe the basic human, material, natural, informational, financial, and technological **resources** associated with alternate energy systems (e.g., storage batteries, geothermal deposits, capital).

C. Identify and evaluate **career** opportunities associated with alternate energy systems (e.g., civil engineer, wind generator technician, farmer) based on their interests, talents, and career expectations.

D. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when using alternate energy systems. PH3

E. Describe the environmental and societal **impacts** associated with various alternate energy systems including visual pollution, decentralization of energy resources, conservation of fossil fuels, land utilization, and higher energy costs. SC2

F. Identify basic **applications** for alternate energy systems including heating living space, generating electricity, and producing alternate fuels for transportation systems. SC1

G. Summarize the major milestones in the **history** and evolution of alternate energy technologies including the utilization of wind energy by the Dutch in the 1600's, the building of Hoover Dam, and the introduction of gasohol. SS2

H. Describe the harnessing, conversion, storage, control, and distribution **processes** used in wind, geothermal, ocean thermal, tide, wave, hydroelectric, ocean current, nuclear and biomass energy systems. SC1

I. Design, build, test and present working models of alternate energy systems like wind generators, hydroelectric turbine/generators, and geothermal power plants.

J. Select and defend the best alternate energy system for a given problem based on geographic, societal, environmental, monetary, safety, and technological consideration. SC2

K. Determine the amount of energy produced by an alternate energy system using appropriate measuring tools and units. SC4

L. Forecast what the world will be like when fossil fuel energy resources become too expensive to use at the current rate. SC2

M. Evaluate relationship between the need to utilize alternate energy resources and the need to preserve our natural resources. SC2

N. Assess the cost-effectiveness of using a given alternate energy resource based on a given time frame, current energy cost, the cost of implementing an alternate energy system, and the amount of energy produced.

O. Select and defend the optimum alternate energy technology to supplement the energy needs of a household, enterprise or community.

P. Forecast the potential effects of alternate energy systems on fossil fuel utilization, energy costs, pollution, and lifestyles. SC2

Suggested Learning Experiences

1. Explain how waste products like garbage, manure, and crop residue can be processed into biofuels. During a laboratory activity, have students process old newspapers into fireplace logs by soaking them in water, rolling them into tight logs, securing them with wire, and allowing them to dry. Ask students to identify other common waste products that could potentially be used as energy resources.
2. Discuss how to harness the wind's mechanical energy to generate electricity. Using common woodworking tools, have students shape small strips of wood into wind turbines. Fasten each turbine to a hobby motor mounted on a base and connected to a voltmeter. Position a portable fan a given distance from each model wind generator. Assess the relationship between wind velocity and output energy by moving the fans closer to the wind generators while monitoring the voltage produced by the hobby motors. Ask students to evaluate how variables like wind speed, generator efficiency, blade pitch, and turbine weight and balance affect the wind energy conversion process.
3. Discuss the rediscovery of wind energy due to the high cost and questionable supply of fossil fuel. Using a small bicycle, automotive, or industrial generator, build a wind generator on school grounds. Connect the wind generator to an energy meter and a load (e.g., sign, storage batteries). Monitor the energy produced by the generator for a long period of time. Use the data collected to evaluate the potential and cost-effectiveness of utilizing wind energy in your area. Ask students to identify the advantages, disadvantages, and potential applications of their wind generator.
4. Introduce students to the concept of a wind farm. Have students wire a series of model wind generators together. Using several portable fans, determine the amount of energy produced by the model wind farm. Use the wind farm to illuminate a bulb or power a small motor. Ask students to evaluate the practicality of using wind farm technology to generate electrical energy for your community. Include considerations like land utilization, safety, storage and distribution in your discussion.
5. Discuss how the mechanical energy in moving water can be used to generate electricity. Have students design and build model

hydroelectric generators using things like sheet metal, hobby motors, copper tubing, and plastic hose. Connect each hydroelectric turbine/generator to a water distribution manifold connected to a hose bib. Control the pressure produced by adjusting the hose bib valve and using a small orifice to restrict the water striking each turbine. Measure the voltage produced by each turbine/generator. Try illuminating an LED or light bulb with one or more model hydroelectric generator.

6. Introduce students to the concept of geothermal energy. Consider simulating a geothermal deposit by putting water into a sauce pan, covering it with aluminum foil, securing the foil with wire, puncturing the foil with a nail, and placing the assembly on a hot plate. When the water begins to boil, the foil will swell and steam will escape through the hole. Discuss how the hot plate represents super heated rock, the sauce pan and water represent a geothermal deposit, and the aluminum foil represents the earth surrounding a geyser or geothermal well. Ask students how to harness the thermal and mechanical energy produced by the pressurized steam. Explain how geothermal energy is being used to heat living space and generate electricity.

7. Explain how geothermal energy trapped underground can be used to generate electricity. Have students design and build model geothermal power plants using things like sheet metal hobby motors, copper tubing, and plastic hose. Connect each geothermal power plant to a beaker positioned above a heat source. Boil the water and use the steam to drive the turbine driven generator. Use a small orifice to restrict the steam and produce the pressure needed to turn the turbine.

8. Discuss how biomass can be converted to methane gas using anaerobic digestion. Using materials like buckets, glass jugs, aquarium heater, sewage, manure, and algae, have students make and test an anaerobic digester. Include tasks like maintaining temperature, monitoring gas production, and burning the collected gas. Analyze the role of anaerobic digestion as an appropriate technology in third world countries. Ask students to evaluate the role appropriate alternate energy technologies could play in the United States.

9. Explain how biomass materials can be converted to methane gas by means of a pyrolytic converter. Using materials like test tubes, glass tubing, rubber hose, and scraps of wood, have students construct and test a pyrolytic converter. Include tasks like burning wood, collecting gas, igniting the gas, and analyzing the ash. Discuss how the pyrolytic process can be used to convert materials like garbage, wood, and coal into methane gas. Ask students to describe and evaluate the role pyrolytic technology might play as our natural gas deposits dwindle.

10. Introduce students to the concept of a heat pump. Using large buckets of hot and cold water, a plastic bottle, and a balloon, demonstrate how heat can be moved from one fluid to another. Have a student fasten the balloon across the mouth of the bottle, place it in the hot water, watch the balloon expand, transfer the bottle/balloon

to the cold water, and watch the balloon deflate. Ask students to explain how the thermal energy is being moved and how the energy could be tapped to generate electricity.

11. Discuss how heat from the air, ground, or bodies of water can be extracted and used to heat living spaces and someday, generate electricity. Using components from a discarded refrigerator, have students design, build, and test a heat pump that moves heat from one sealed enclosure to another. Calculate and compare the amount of energy used to power the system and the heat gain in the enclosure. Ask students to identify the potential problems and application for heat pump technology.
12. Discuss the career opportunities in alternate energy systems. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to alternate energy systems. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.
13. Discuss the milestones in the history of alternate energy systems. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

Suggested Learning Objectives

Upon completion of the solar energy unit, students will be able to:

A. Define and properly use common solar energy **terminology** like glazing, insulation, thermal mass, and air stratification. SC1

B. Describe the basic human, material, natural, informational, financial, and technological **resources** associated with solar energy utilization (e.g., site, thermal mass, heat transfer fluid).

C. Identify and report the major milestones in the **history** and evolution of solar energy technology including the development of native American cliff dwellings, photovoltaics, and solar farms. SS2

D. Identify and evaluate **career** opportunities associated with solar energy utilization (e.g., solar home designer, solar energy systems installer, photovoltaic lab technician) based on their interests, talents, and career expectations.

E. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when using solar energy. PH3

F. Identify the basic **applications** for solar energy technologies including heating living space, heating water, powering electronic devices, providing a climate for growing plants, and generating electricity. SC1

G. Identify the technological **impacts** of solar energy technology including decentralization of energy resources, life style changes, new architectural styles, conservation of fossil fuels, and visual pollution. SC2

H. Describe the basic solar energy **processes** like collecting, storing, controlling and distributing.

I. Forecast the potential effects of solar energy utilization on things like fossil conservation, building costs, air pollution, and lifestyle. SC2

J. Identify the basic elements required to collect, convert, distribute, store, and control energy from the sun.

K. Distinguish between and identify examples of direct, indirect, and isolated gain passive solar energy systems. SC1

L. Evaluate how geographical, seasonal, and technological variables affect the cost-effectiveness and energy efficiency of solar energy technologies. SC2

M. Compare and contrast the cost-effectiveness of a given solar energy system based on the cost of fossil fuel energy, the costs associated with solar energy technology, and the system performance. SC2

N. Describe the advantages and disadvantages of air and hydronic active solar energy systems. SC2

O. Describe the collection, conversion, storage, control, and distribution technologies used in passive, active, photovoltaic, and large scale solar energy systems.

P. Design, build, and test a small scale solar energy system that addresses a simple thermal or electrical energy problem.

Q. Analyze and present the best solar energy system for a given problem based on design, energy, cost, and aesthetic considerations.

R. Apply basic mathematical concepts to do things like determine heat gain, identify solar collector orientation, angles, and calculate the power produced by a photovoltaic device. MA1

S. Design, build, test and evaluate simple solar energy devices like parabolic collectors, flat plate collectors, greenhouses, solar farms, solar furnaces, or photovoltaic arrays.

T. Identify opportunities and develop strategies for integrating solar energy technology into a given structure.

U. Determine the amount of energy produced by a thermal and electrical solar energy system using appropriate tools, techniques, and measuring units.

V. Describe the limitations of solar energy technologies for industrial, commercial, and residential applications. SC2

W. Identify solar energy as an appropriate and viable means of reducing our dependence on fossil fuels.

Suggested Learning Experiences

1. After introducing the basic passive solar energy concepts and techniques, have groups of students design, build and test a variety of models representing direct, indirect, and isolated gain systems. Have students monitor the interior temperatures of the models in the sun and in the shade. Discuss the advantages, disadvantages of each design. Ask students to forecast what it would be like to live or work in various types of passive solar buildings.
2. After discussing the basic active solar energy concepts and techniques, have groups of students design, build and test a variety of solar collectors. Include flat plate, parabolic, air, and liquid collectors. Have students compare the input and output temperatures of the fluid being circulated through the collectors. Discuss the advantages, disadvantages, and potential applications of each solar collector design.
3. Explain how solar energy technologies can be integrated into a building's design. Provide students plans for a simple structure (e.g., vacation cottage, farm building, room addition). Have students modify the plans or build models showing how passive and/or active solar energy technologies can be incorporated into the

design. Make sure students account for collection, storage, distribution, control, and aesthetic considerations. Discuss how using solar energy technologies is changing architectural and life styles.

4. Discuss how solar energy can be used to generate electricity for a community with solar farm or solar central receiver technology. Using common materials, have students build a working model of a solar central receiver and/or linear parabolic solar farm. Ask students to evaluate the cost, efficiency and land requirements associated with large scale solar energy systems.

5. Discuss how solar energy can be used to heat water for domestic and industrial applications. Have students design, build, and test a passive or active solar energy system to heat a given quantity of water. During the testing process, monitor the temperature of the water and calculate the heat gain in BTU's. Ask students to identify the problems associated with heating water with solar energy.

6. After introducing the greenhouse effect, have groups of students construct simple greenhouses using polyethylene plastic, staples, and wood on a site with a good solar orientation. Monitor the temperature inside the greenhouse at various times of the day for several weeks. Locate plantings both inside and outside the greenhouse and compare their development over time. Discuss how greenhouses can be used to grow plants year round and for heating living space.

7. Explain how solar radiant energy can be directly converted into electrical energy using photovoltaic technology. Using one or more photovoltaic cell(s), have students determine electrical energy produced. Using the cost of cell(s) and their energy output, have students calculate the cost of powering one 100 Watt light bulb using photovoltaic technology. Evaluate the cost-effectiveness of photovoltaic technology and the potential applications and impacts if they become affordable.

8. Discuss how photovoltaic technology is being used to power calculators and satellites. Have students design, build, and test a solar power device that addresses a given problem. Problems could include recharging batteries, measuring light, circulating air through a collector and powering a model vehicle. Ask students to identify other appropriate applications for photovoltaic technology.

9. Discuss the basic elements needed to harness energy from the sun (e.g., enclosure, glazing, flat black absorber surface, thermal mass, insulation). Provide students a wide variety of easy-to-use materials including things like aluminum foil, cardboard, duct tape, fiberglass insulation, glass jars, pea gravel, and polyethylene plastic. Have each student modify a shoe box or similar container so it will collect, convert, distribute, store, and control energy from the sun. Test the collectors outdoors and record the temperatures produced in the sun and maintained in shade. Evaluate the various materials and techniques used to maximize solar collector performance. Ask students to identify which designs seem to be the most useful.

10. Discuss how climate and location affect the orientation and performance of solar energy collection devices. Have students monitor energy output while experimenting with various solar altitude and azimuth angles to a given light source. Discuss how orientation and tracking techniques maximize solar collector and photovoltaic performance. Ask students to identify good and bad locations for solar energy utilization based on climate and available solar radiant energy.

11. Discuss the milestones in the history and evolution of solar energy systems. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

12. Discuss the career opportunities in solar energy utilization. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to solar energy utilization. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

Addresses

The following list of addresses is provided for teachers desiring additional information:

Illinois Vocational Curriculum Center (IVCC)
Sangamon State University F-2
Springfield, IL 62708
800/252-8533

American Vocational Association (AVA)
828 South 2nd Street
Room 403
Springfield, IL 62704
217/433-0815

Curriculum Publications Clearinghouse
Western Illinois University
Horrabin Hall 46
Macomb, IL 61455
800/322-3905

Center for Implementing Technology Education
Department of Industry & Technology
Ball State University
Muncie, IN 47306

Technology Student Association (TSA)
University of Illinois
Department of Vocational & Technical Education
1310 S. Sixth Street
Champaign, IL 61820

Illinois Vocational Association (IVA)
44 Emporia Avenue
Springfield, IL 62702

American Technology Student Association (ATSA)
1908 Association Drive
Reston, VA 22091
703/860-9000

International Technology Education Association (ITEA)
1914 Association Drive
Reston, VA 22091

Illinois Industrial Technology Education Association (IITEA)
44 Emporia Avenue
Springfield, IL 62702

Department of Adult, Vocational and Technical Education
Program Improvement Section
100 North First Street
Springfield, IL 62777

U.S. Department of Energy
Office of Public Affairs
1000 Independence Ave. SW
Washington, DC 20585

Energy DOE
P. O. Box 62
Oak Ridge, TN 37830

Illinois Dept. of Energy and Natural Resources
Energy Information
Clearinghouse
325 West Adams Street
Springfield, IL 62706

U.S. Environmental Protection Agency
Publications Office
401 M. Street, S.W.
Washington, DC 20460

Carol Henry
Mix Coordinator
Gregg Division - McGraw Hill Book Company
New York, NY 10020
(314) 256-2222
The Technology Link

Software

The following partial list of software is offered to help teachers identify programs having potential for application in technology courses:

TEMPERATURE: PLAY SCIENCE
Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570

THE SCIENCE TOOL KIT
Broderbund Software
17 Paul Drive
San Rafael, CA 94903

THREE MILE ISLAND
Muse Software
347 N. Charles Street
Baltimore, MD 21201

BASIC CONCEPTS OF ELECTRICITY
Merian Scientific
247 Armstrong Ave.
Georgetown, Ontario
Canada L7G 4X6

DESIGN-A-CIRCUIT II
Computer Aided Instruction Systems
Box 177
Holly, MI 48442

HI-RES ELECTRONIC DESIGN
Avant-Garde Creations
Eugene, OR 97403

ENERGY HOUSE
HEATLOSS
Minnesota Educational Computing Consortium (MECC)
2520 Broadway Drive
Lauderdale, MN 55113

WIND ENERGY CALCULATIONS
Charles O'Neill
Elk City, OK 73644

HOME ENERGY CONSERVATION
Educational Materials and Equipment Co.
Pelarm, NY 10803

BASIC ELECTRICITY & ELECTRONICS FOR DIRECT CURRENT
Career Aids Inc.
20417 Nordhoff St.
Chatsworth, CA 91311

TEMPERATURE GRAPHER
POWER GRID
ELECTRIC BILL
PERSONAL ENERGY INVENTORY
Human Relations Media
175 Tompkins Avenue
Pleasantville, NY 10570-9973

ROCKY'S BOOT
The Learning Company
545 Middlefield Road Suite
170 Menlo Park, CA 94025

CREATIVE CONTRAPTIONS
Bantam Software
666 Fifth Avenue
New York, NY 10103

Books

The following textbooks will contain information that will help teachers prepare to teach technology courses.

Anderson, B. (1977). *Solar energy: Fundamentals in building design.* New York: McGraw-Hill.

Anderson, B., & Wells, M. (1981). *Passive solar energy.* Andover, MA: Brick House.

Bame, E. A., & Cummings, P. (2nd. ed.). (1980). *Exploring technology.* Worcester: Davis.

Cook, J. G., & The Thomas Alva Edison Foundation. (1988). *The Thomas Edison book of easy and incredible experiments.* New York: Dodd, Mead & Co.

Deane, Q. (Ed.). (1982). *How it works.* New York: Grenwich House.

DeVito, A., & Krockover, G. H. (1981). *Activities handbook for energy education.* Santa Monica: Goodyear.

Fales, J. F., Kuetemeyer, V. F., Brusic, S. K. (1988). *Technology: Today and tomorrow.* Mission Hills, CA: Glencoe.

Fay, P., Pickup, R., Braithwaite, C., & Hall, J. (1980). *Modular courses in technology: Electronics.* Edinburgh: Schools Council.

Feldman, A., & Gunston, B. (1980). *Technology at work.* New York: Facts on File.

Frazer, F. (1981). *Discovering energy.* London: Cobblestone Books.

Garrison, J. A. (1981). *Solar projects.* Philadelphia: Running Press.

Goetsch, D. L., & Nelson, J. A. (1987). *Technology and you.* Albany: Delmar.

Hacker, M., & Barden, R. A. (1988). *Living with technology.* Albany: Delmar.

Hacker, M., & Barden, R. A. (1987). *Technology in your world.* Albany: Delmar.

Harms, H. (Ed.) (1988). *Energy, power, and transportation: Technology activities.* Albany: Delmar

Harpur, P. (Ed.). (1982). *The timetable of technology.* New York: Hearst.

Hydraulics. (1982). Moline: Deere.

Hydraulics: Compact equipment. (1982). Moline: Deere.

Karwatka, D., & Kozak, M. R. (1987). *Discovering technology: Energy, power and transportation.* Orlando: Harcourt Brace Jovanovich.

Miller, G. T., Jr. (1980). *Energy and environment: The four energy crises* (2nd ed.). Belmont, CA: Wadsworth

Mims, F. M. III. (1983). *Getting started in electronics.* Fort Worth: Tandy

Minton, G. D., & Minton, B. K. (1987). *Teaching technology to children.* Worcester: Davis.

Patient, P., Pickup, R., & Powell, N. (1983). *Modular courses in technology: Pneumatics.* Edinburgh: Schools Council.

Prenis, J. (Ed.). (1975). *Energy Book 1: Natural sources & backyard applications.* Philadelphia: Running Press.

Prenis, J. (Ed.). (1977). *Energy Book 2: More natural sources & backyard applications.* Philadelphia: Running Press.

Sage, J., Flower, R., Kinsman, P., Morgan, A., & Perrott, J. (1980). *Modular courses in technology: Energy resources.* Edinburgh: Schools Council.

Schwaller, A. E. (1989) *Transportation, energy, power technology.* Albany: Delmar.

Smith, H. B. (1985). *Exploring energy: Sources/applications/alternatives.* South Holland: Goodheart-Willcox.

Taylor, P. (1982). *The kids' whole future catalog.* New York: Random House.

Todd, R., McCrory, D., & Todd, K. (1985). *Understanding and using technology.* Worcester: Davis.

U. S. Department of Energy. (1981). *Home wind power.* Charlotte: Garden Way.

U. S. Department of Energy, National Solar Data Program. (1979). *Active solar energy system: Design practice manual.*

Williams, C. F., Badrkhan, K. S., & Daggett, W. R. (1985). *Technology for tomorrow.* Cincinnati: South Western.

Williams, C. F., Badrkhan, K. S., & Daggett, W. R. (1985). *Technology at work.* Cincinnati: South Western.

Walker, J. R. (1981). *Exploring power technology: Basic fundamentals.* South Holland: Goodheart-Willcox.

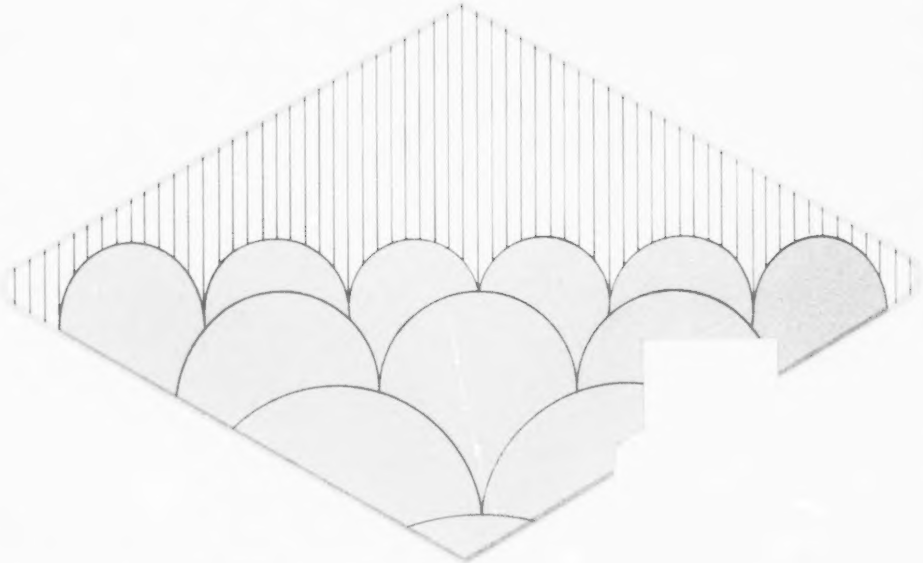
Manuals

Manuals available from the Curriculum Publications Clearinghouse, Western Illinois University, Horrabin Hall 46, Macomb, IL 61455, 800/322-3905:

- Strategies for Problem Solving
- Transition Training: Manual for Personal Growth, Development and Self-Improvement
- The Vocational Ethics Manual
- Generalizable Communications Skills Assessment: User Manual
- Generalizable Communications Skills Assessment: Resource Directory

- Generalizable Interpersonal Skills Assessment: User Manual
- Generalizable Interpersonal Skills Assessment: Resource Directory
- Generalizable Mathematics Skills Assessment: User Manual
- Generalizable Mathematics Skills Assessment: Resource Directory
- Generalizable Reasoning Skills: User Manual
- Generalizable Reasoning Skills: Resource Directory

Production Technology Curriculum Guide



PRODUCTION TECHNOLOGY

Course Rationale

Throughout history, people have produced goods, constructed shelters, and provided services. Society places a high priority on these activities to improve the quality of life and facilitate economic growth. In order to maintain a high standard of living and continue economic development, these activities must constantly undergo significant changes. Changing technology has made it possible for industries to produce goods, construct structures, and provide services with more efficiency, greater accuracy, and fewer people.

The study of Production Technology can help students to develop an appreciation of the hands-on activities, technical advancements, technological impacts, and employment trends found within the manufacturing, construction, and servicing industry. Through learning experiences that include problem solving, decision making, group interaction, and technical development, a student can become more technologically literate. As a result of technological literacy, students will be better equipped to make rational career decisions, be wiser consumers, and cope with future technological advancements.

Since the educational system should provide curriculum conducive to developing a person's understanding of the world, then a study of materials and processes, manufacturing, construction, and servicing becomes a valid, and significant part of a student's plan of study. The production course can provide opportunities to learn content that is unique to the student's high school experience. There is no other area of the high school curriculum that can offer the student a chance to examine how our society produces, constructs, and services its goods, products, and structures. Through activities which employ a wide range of tools and materials in conjunction with extensive planning and processing skills used in industry, this course promotes an understanding of an industrial/technological society.

Course Mission

The purpose of the Production Technology course is to orient students to the basic resources, technical processes, industrial applications, and technological impacts related to manufacturing, construction, and servicing technology. The course will help students to:

- use and understand the verbal and symbolic language used to describe production systems and phenomenon;
- develop and present creative solutions to present and future production problems;
- identify and investigate potential career opportunities in the area of production;
- understand the evolution of production technology and its influence on our culture; and

- safely use common tools, materials and processes to design, build, and test production systems.

Course Description

The Production Technology course includes units on materials and processes, manufacturing, construction, and servicing. Each unit will involve students in a wide range of activities and experiences. Students' learning activities and experiences will include things like managing and organizing people; researching and developing products; producing and assembling goods; designing and building structures; testing and evaluating materials; generating plans and specifications; installing and servicing systems; and marketing and distributing finished goods.

Course Outline

In the spirit of orientation, students should be introduced to a wide range of materials and processes, manufacturing, construction, and service technologies. The following course outline lists the recommended units for either a nine or an eighteen week format. Potential lesson topics are provided under each unit title. Each lesson should embrace as many of the unit objectives as possible. In a nine week format, an emphasis should be placed on the terminology, resources, processes, applications, impacts, careers and safety concepts that relate to the lesson topic.

Sample Production Technology Course Outline

I. Introduction to Production Technology

II. Materials and Processes
    A. Materials
    B. Separating
    C. Forming
    D. Combining
    E. Molding/Casting
    F. Finishing
    G. Safety

III. Construction
    A. Design Engineering
    B. Surveying and Preparating the Site
    C. Establishing Foundation System
    D. Building Superstructures
    E. Installing Utilities
    F. Enclosing and Finishing
    G. Marketing

IV. Manufacturing
    A. Establishing Enterprises
    B. Financing Enterprises
    C. Research and Development
    D. Industrial Engineering
    E. Production
    F. Marketing
    G. Industrial Relations
    H. Dissolving Enterprises

V. Servicing
    A. Installing
    B. Maintaining
    C. Repairing

Adapting the Production Technology Course Outline to a Nine or Eighteen Week Format

Hands-on learning activities are one of the most powerful ways of helping students learn about technology. Unfortunately, they are very time-consuming. The following strategies can be employed to use available laboratory time more efficiently without sacrificing important unit objectives:

- Divide the class into small groups and assign each group a different learning activity related to the lesson topic. When each group has finished their assigned activities, have students present their experiences to the rest of the class. For example, during the materials and processes unit, have groups of students perform a variety of processes on different materials.
- Avoid assigning complex laboratory activities when simpler activities will enable students to experience important concepts and achieve the desired objectives. For example, during the manufacturing unit, have students manufacture a product with less than six parts instead of one with ten or more parts.
- Prepare work stations that organize the tools and materials needed to conduct laboratory activities prior to class. For example, during the servicing unit, develop the mock-ups students will use to install and service burglar alarms.
- Have students experience a wide range of concepts through one or two robust learning activities. For example, during the materials and processes unit, have students cast polystyrene beads. Discuss how the basic processes used to cast polystyrene beads transfer to other materials like polymers, ceramics, and metals.

During an eighteen week format, students can engage in more complex learning activities and experience given topics in greater depth. In addition, there is an opportunity to provide a wider range of learning experiences. The study of technology allows for an infinite number of learning experiences. Therefore, it is important to select and implement learning activities in an efficient manner.

INTRODUCTION TO PRODUCTION TECHNOLOGY

Suggested Learning Objectives

Upon completion of the Introduction to Production Technology unit, students will be able to:

A. Define and properly use common production technology terminology like development, engineering, quality control, industrial service, management, and contracting.

B. Categorize production activities like building bridges, assembling automobiles, and repairing computers as manufacturing, construction, or servicing.

C. Describe the basic applications for production technology including making products, building structures and servicing goods.

D. Compare and contrast the roles of manufacturing, construction, and servicing on the American and international economy. SS1

E. Describe the role of planning, organizing, staffing, directing and controlling in managing manufacturing, construction, and servicing activities and enterprises.

F. Describe the basic types of tools, materials, and processes used to produce goods, build structures, and provide services.

G. Explain why and how people work together in manufacturing, construction and service enterprises.

H. Recognize and provide examples of manufacturing, construction, and service industries in the community.

I. Forecast the consequences of low productivity and describe the technological strategies being used to enhance the United States' competitiveness in international markets. SC2

Suggested Learning Experiences

1. Introduce students to the concept of manufacturing. Describe manufacturing as those activities performed within a facility to produce a product. Using teacher-prepared jigs and fixtures and materials like balsa wood, cardboard, tooth picks or drinking straws, have students report to workstations and manufacture trusses for a bridge. Based on this experience, ask students to explain the importance of planning, cooperation, quality control, and efficiency when manufacturing products.

2. Introduce students to the concept of construction. Describe construction as those activities conducted on a site to build a structure. Using the trusses produced during the activity above, have groups of students construct a model bridge on a fixture

representing a building site. Ask students to identify similarities and differences between manufacturing and construction.

3. Introduce students to the concept of servicing. Describe servicing as those activities performed to install, maintain, or repair finished products and structures. Using a teacher-prepared testing apparatus, have students apply a load to their bridge until it fails. Ask each group to determine why their bridge failed, identify appropriate modifications, and make necessary repairs. Have students discuss the relationship between manufacturing, construction, and service activities.

4. Discuss how manufacturing, construction, and service organizations contribute to a community's economy. Using reference materials like telephone books and/or newspapers, have students review advertisements and categorize local companies under the headings of manufacturing, construction, and service. Have students discuss the employment opportunities and the number of enterprises in each category. Ask students to determine the category making the biggest contribution to the local economy.

5. Discuss the new innovations and trends in production technology. Using magazines and newspapers with a wide circulation, have small groups of students make bulletin board displays identifying and illustrating the current trends in manufacturing, construction, and service industries. Ask students to describe the impact of new developments in production technologies on employment patterns, education requirements for employment, and quality of life.

6. Introduce students to a variety of manufacturing, construction, servicing, material and processing technologies. Include things like computer-aided design, computer-aided manufacturing, surveying, advertising, composites, and servicing products. Assign each student a topic and ask them to develop a display describing their assigned production technology topic. Each display should identify the people and tools associated with the production process. In addition, have students identify if the process is performed within a facility or on a site.

MATERIALS AND PROCESSES

Suggested Learning Objectives

Upon completion of the Materials and Processes unit, students will be able to:

A. Define basic material properties like strength, stiffness, plasticity, hardness, toughness, opacity, and ductility. SC1

B. Interpret concepts like conditioning, bonding, fastening, shearing, turning, and extrusion.

C. Define and properly use common materials and processes **terminology** like malleability, casting, lamination, alloy, renewable, and polymer.

D. Identify the major milestones in the **history** and evolution of material and process technology, including things like the bronze age, the development of plastic, and the introduction of computer numerical control. SS2

E. Identify basic **applications** for materials and processes technology like building structures, manufacturing products, processing raw materials, and providing services.

F. Describe the major **processes** used in materials and processes technology including forming, separating, combining, fastening, molding, casting, conditioning, and finishing.

G. Identify basic natural, human, material, financial, technological, and information **resources** used in materials and processes enterprises (e.g., iron ore, metallurgists, machines, land).

H. Identify, describe, and evaluate **career** opportunities related to the materials and processes (e.g., machine operator, tool and die maker, forest manager) based on their interests, talents, and career expectations.

I. Identify potential **safety** hazards and establish guidelines for safe behavior when handling and processing materials in both manufacturing and construction contexts.

J. Forecast the environmental **impacts** associated with obtaining raw materials, processing materials, and disposing of waste materials. SC2

K. Identify characteristics and examples of ferrous metals, nonferrous metals, hardwoods, softwoods, thermoplastics, thermoset plastics, ceramics, and composites.

L. Identify materials that can be recycled and describe how they are collected, sorted, and reprocessed.

M. Describe and accurately use the tools and techniques used to measure and lay out common materials of various shapes. MA3

N. Describe the tools and techniques used in manufacturing and construction to separate, cast, mold, form, assemble, condition, and finish common materials including polymers, metals, ceramics, and composites.

O. Determine the raw materials, primary processes, and secondary processes used to make a given product structure.

P. Test and describe the mechanical, physical, thermal, chemical, electrical, optical, and acoustical properties of polymers, metals, ceramics, and composites. SC1

Q. Safely use common tools, machines, and equipment to perform basic material processes like sawing, soldering, bending, molding, riveting, and heat treating.

R. Identify and categorize common materials as polymers, metals, ceramics, or composites.

S. Select an appropriate material for solving a given manufacturing or construction problem based on its properties, cost effectiveness, and environmental impact

T. Conserve natural resources by minimizing waste when selecting, processing and using materials.

U. Apply basic mathematical concepts to do things like measure materials, calculate area and volume, layout angles, and convert units. MA1

V. Participate in community recycling projects by contributing recyclable materials.

W. Evaluate and utilize aesthetic characteristics when selecting and processing polymers, ceramics, metals, and composite materials.

X. Forecast the potential effects of new materials and processes on things like manufacturing and construction practices, product durability, and recycling techniques. SC2

Suggested Learning Experiences

1. Discuss the fact materials have various mechanical properties (e.g., strength, elasticity, plasticity, hardness, toughness). Divide the class into teams and provide each team a problem requiring a material with specific mechanical properties. Using commercial or constructed testing equipment, have students measure and compare the tensile, compression, shear, and torsion strength of various materials. Have students use the data they collect to select and recommend the best material for solving the problem.

2. Explain how materials can be classified into basic categories (e.g., metal, polymers, ceramics, composites) and subcategories (e.g., hard woods, soft woods, ferrous metals, nonferrous metals, thermoplastic, thermoset plastics). Demonstrate how to perform a simple test to categorize materials. Include things like inspecting end grain, checking metals with a magnet, and testing plastics over a small flame. After the demonstration, have students identify and categorize sample materials into their basic groups and subgroups.

3. Discuss the fact that some materials have special properties that make them appropriate for specific applications. Provide teams of students with design specifications for a product. Include the electrical, mechanical, thermal, magnetic, aesthetic, and chemical considerations. Have students use simple tools to evaluate a variety of material samples (i.e., electrical conductivity, thermal conductivity, corrosion resistance, mechanical properties) for strength. Using the data they collect, have students evaluate, recommend, and present the material that meets the design specifications.
4. After analyzing the importance of recycling materials, have students conduct a recycling campaign. Begin by identifying recycling opportunities in your community and evaluating the most cost-effective material to recycle (e.g., glass, newspaper, ledger paper, aluminum cans). Have students develop and implement strategies to collect, sort, store, and transport the material being recycled. Have students keep accurate records regarding the materials collected and report the results of the recycling campaign to the school community. Evaluate if recycling has been a help to the community.
5. Discuss the environmental impacts associated with disposing of materials. Have students conduct a degradability study by weighing and burying a variety of waste materials about one foot underground. Include a variety of paper, wood, plastic, and metal in the experiment. After about 4 to 6 months, dig up, clean, dry, and weigh the waste materials. Divide each material's decomposed weight by its original weight to determine what percentage of the material's mass decomposed during the test period. Compare the results and determine which materials decompose faster than others. Ask students what they can do to reduce the amount of material that goes into their local landfill.
6. Introduce students to plastic as an industrial material. Discuss how it is being used to make medical supplies, toys, automobile parts, and packaging. Have students make several simple plastic parts, products, or structures. Their lab activities could include processes like sawing, fracturing, forming, vacuum forming, casting, dip fastening, and polishing plastic. Emphasize the basic concepts associated with each process and discuss how they transfer to a variety of industrial situations. Ask students to identify the advantage and disadvantage of using plastic to make various products.
7. Discuss how wood is a renewable material resource that can be used to make a variety of products including homes, furniture, and musical instruments. Have students make several simple wood parts, products or structures. Their lab activities could include processes like crosscutting, ripping, planing, squaring, routing, turning, laminating, forming, joining, fastening, gluing, and finishing. Emphasize the basic concepts associated with each process and discuss how they transfer to a variety of industrial situations. Ask students to describe the characteristics of wood that make it an appropriate material for various applications.
8. Introduce students to a variety of metals. Discuss how metal has evolved as an industrial material. Have students make several sim-

ple metal parts, products or structures. Their lab activities could include processes like sawing, casting, forging, hardening, tempering, turning, milling, spot welding, arc welding, brazing, soldering, fastening, plating, and finishing. Emphasize the basic concepts associated with each process and discuss how they transfer to a variety of industrial situations. Have students compare and contrast the advantages and disadvantages of metal with other industrial materials.

9. Introduce students to the concept of measurement. During laboratory activities, have students use a variety of measuring tools and units to describe and lay out materials. Demonstrate and have students measure sheet, rectangular, and cylindrical stock, use metric and English measuring units, calculate area and volume, layout angles, minimize waste, and accentuate the aesthetic characteristics of various materials. Discuss the importance of accurate measurement in a variety of industrial contexts.

10. Explain how various materials and processes are used to make a given product. Divide the class into teams and provide each team a product. Have each team make a display illustrating the basic materials and processes used to manufacture their assigned product. Make sure students include the raw materials, primary processes, secondary processes and environmental protection and restoration processes (e.g., filtering pollutants, replanting forests, land reclamation). Explain how designers and engineers select materials for a product or structure.

11. Provide teams of students a manufacturing or construction problem statement that requires the selection of a material for their solution. Have students identify materials, determine the cost, aesthetic, processing, and environmental considerations associated with each option, and select and defend the best materials to use to solve the problem.

12. Discuss the milestones in the history and evolution of materials and processes technology. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

13. Discuss the career opportunities in materials and processes technology. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to materials and processes technology. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

CONSTRUCTION TECHNOLOGY

Suggested Learning Objectives

Upon completion of the construction technology unit, students will be able to:

A. Define and properly use common construction **terminology** like anchorages, cantilever, prefabrication, renovating, modular, liens, and geotextiles.

B. Identify basic **applications** for construction technology like constructing shelters, providing facilities for recreation and entertainment, establishing pathways, and building structures.

C. Describe the societal and environmental **impacts** associated with construction activities including eliminating wildlife habitats, altering landscapes, urbanization, and enhancing the quality of life. SC2

D. Describe the advantages, disadvantages, and potential **applications** for alternative building techniques and materials including pneumatic, geodesic, and fabric structures. SC2

E. Categorize the major **processes** used to construct buildings, structures, and pathways including designing the project, preparing the site, establishing the foundation system, erecting a superstructure, installing utilities, and enclosing and finishing structures.

F. Identify, describe and evaluate **career** opportunities in the construction industry (e.g., laborer, contractor, iron worker, architect) based on their interests, talents, and career expectations.

G. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when around or participating in construction activities. PH3

H. Describe the major milestones in the **history** and the development of construction technology including building of the pyramids in Egypt, introduction of the arch, construction of the Panama Canal and the development of prefabricated components and structures. SS2

I. Identify basic natural, human, material, financial, technological, and information **resources** used in construction enterprises (e.g., lumber, construction loans, building codes).

J. Apply the concept of tension and compression to design, build and evaluate a structure that will distribute and carry a given load. SC1

K. Assess the load carrying characteristics of various geometric shapes and configurations including arches, I- beams, trusses, domes, and hyperbolic paraboloid. SC2

L. Apply basic management processes like planning, organizing, staffing, directing and controlling to maximize efficiency during simple construction projects.

M. Describe the utility systems and services associated with structures, buildings, and pathways including sewage, electricity, natural gas, telephone, cable, and water.

N. Describe the various foundation systems used to distribute the weight of structures, buildings, and pathways including piles, piers, spread footings, and floating slabs.

O. Evaluate communities based on design considerations like providing utilities, establishing transportation systems, planning for expansion and zoning for residential housing, commercial buildings, and industrial parks.

P. Use common tools, techniques and math principles to perform construction processes like engineering, surveying, squaring, leveling, estimating, and measuring. MA1

Q. Forecast the potential effects of innovative construction techniques on things like labor patterns, housing, energy utilization, and building time. SC2

R. Design, build, test and evaluate a construction model, mock-up, or project that addresses a construction problem featuring cost, time, environmental, and/or societal considerations.

Suggested Learning Experiences

1. Demonstrate how folding and bonding materials can increase their load carrying capacity. Using a given amount of paper and glue, have each student design, build, and test paper structures that will carry a given load in either a vertical or horizontal position. Ask the students to describe how their structure distributes its load.

2. Demonstrate how trusses and beams are used to increase the strength of structures. Using a given amount of balsa wood, glue, straight pins, and a testing fixture, have each student design, build, and test a truss or beam. Have the students describe how their truss or beam distributes its load.

3. Introduce students to the concept of forming a construction enterprise. Divide the class into groups based on the number of construction projects to be addressed. Have each group establish, organize and name a construction company. Each enterprise needs to include an architect, a general contractor, and several subcontractors (e.g., electrician, carpenter, mason). Analyze how the student enterprises compare to real construction companies in your community. Ask students to examine the company's responsibility to provide job and make a profit in a competitive market.

4. Discuss the various jobs and career opportunities in the construction industry. Have students apply and interview for positions in their construction company. Depending on the construction project, create positions that allow students to role play careers in carpentry, masonry, landscaping, general contracting, designing, architecture, and structural engineering. Ask students to summarize the factors needed to obtain a job in the construction industry.

Include things like education requirements, work experience, interpersonal skills, and knowing how to be a good employee.

5. Introduce students to the processes used to design, plan, and engineer construction projects. Using traditional materials or computer-aided drafting and design tools, have a group of students prepare plans, specifications, and a presentation model for a construction project that addresses the needs of a real or fictitious client. The client's needs can be expressed in the context of a storage building, room addition, vacation home, or small office. Have each design and engineering team evaluate their plans and specifications in terms of things like energy, cost, lighting, function, appearance, safety, maintenance, zoning, traffic, and structural considerations.

6. Explain the importance of scheduling to maximize efficiency during a construction project. Have each construction company complete a schedule identifying and sequencing the people, materials, equipment, and processes needed to complete their construction project on time. Make sure each schedule includes things like when given materials should be delivered to the site, when the construction project will be inspected, when students will need special tools, and when students will be performing given tasks. Discuss how the saying "proper prior planning prevents poor performance" applies to the construction industry. Ask students to identify the consequences of poor planning on things like safety, cost, and profit.

7. Introduce students to the processes involved in preparing bids and estimating the cost of a construction project. Using the plans and specifications, basic formulas for estimating materials, labor and price lists, have each subcontractor determine the cost of performing their assigned construction task. Require each subcontractor to prepare and submit a bid to the general contractor. Ask the general contractor to prepare and present a proposal describing the material, equipment, labor, overhead, and total project cost to a real or fictitious client. Ask the students to discuss the consequences of inaccurately estimating and bidding on construction projects.

8. Discuss why communities require builders to obtain building permits before starting construction or remodeling projects. Using a simple check list, have students exchange and evaluate the plans and specifications developed during the activity above. When the plans and specifications meet the defined criteria, grant the student's company a building permit to begin their construction project. Discuss the role of building permits as a means of maintaining community standards and ensuring quality construction.

9. Introduce students to the concept of surveying. Using commercial or constructed transits and level rods, have small groups of students lay out and level four or more stakes for a fictitious construction project. Possible construction projects could include things like decks, garages, or driveways. Discuss the role of surveying in preparing maps, establishing property lines, and laying out pathways.

10. Introduce students to the basic processes used to construct buildings. Using common construction materials, fasteners, tools, equipment, and hardware, have groups of students design and build small storage sheds. Include tasks like establishing a foundation, framing a superstructure, installing a utilities system, and enclosing and finishing the building. Have the students compare and contrast the processes used to build the sheds with those used to build houses, commercial buildings, and industrial complexes.

11. Introduce students to the basic processes used in constructing a building. Include things like preparing the site, establishing a foundation system, erecting the superstructure, installing the utilities, enclosing the superstructure, and finishing the project in your discussion. Using materials like plywood for a site, mortar mix for a foundation system, foam core for the structure, and small electrical components for a utility system, have groups of students build an architectural model for a simple structure (e.g., vacation home, storage building, room addition, small office). Have the students compare and contrast the processes used in designing and building their model with those used in building residential and commercial structures.

12. Introduce students to the concept of pneumatic structures. Using materials like plastic, duct tape, caulking and a fan, have groups of students design, build, test, and present a pneumatic structure that addresses a problem. Possible problems could include developing a new kind of tent, temporary emergency shelters, or enclosing arenas. Ask the students to evaluate the energy requirements, weather resistance, and structural strengths and limitations associated with pneumatic structures.

13. Explain how geodesic domes are structures based on a network of triangles. Using materials like paper, drinking straws, or dowel rods, have small groups of students build a two frequency geodesic dome. Ask the students to discuss the structural strength of domes, how changes in the frequencies affect the dome's shape and size, and the need to connect several geodesic domes together to make a multi-purpose building.

14. Introduce students to the concept of fabric structures. Using material like cloth, string, duct tape, and dowel rods, have groups of students design, build, and present a fabric structure that addresses a problem. Possible problems could include roof to a stadium, pavillian for a park, and/or modern architectural sculpture. Have students compare the structural, cost, engineering, and aesthetic characteristics of fabric structures with conventional structures using traditional building materials and techniques.

15. Present the basic processes used to construct buildings. Using typical construction materials, fasteners, tools, and equipment, have groups of students design and construct a corner section. The corner section should include a foundation, floor, wall, and roof system. Consider having students perform tasks like forming concrete, framing openings, and enclosing the interior and exterior of the structure. Have the students compare and contrast the processes they used to build their corner section with those used to construct homes, commercial buildings and industrial complexes.

16. Explain how foundation systems distribute and transmit structural loads to the earth. Using tools and materials like damp sand, concrete blocks, and masonry tools, have small groups of students construct, level, and plumb a three foot high by six foot long wall. Have students describe the structural and financial implications of a bad foundation system.

17. Introduce students to basic utility systems that are installed during the construction process. Using materials like PVC pipe, receptacles, telephone jacks, and heating ducts, have groups of students install the electrical, plumbing, communication, and climate control systems into the corner section constructed during the activity above. Ask the students to identify the utility systems installed in homes, commercial buildings, and industrial complexes.

18. Introduce students to the concept of building codes and inspection during the construction process. Using a simple check list, have students inspect construction projects being built by other groups. Have students evaluate things like stud spacing, the dimensions of structural members, the number of wires in a junction box, and the size of the plumbing vent stacks. Have students explain why building codes need to be established and enforced. Discuss the consequences of code violations.

19. Introduce students to the concept of community planning. Using materials like cardboard, foam core, balsa, glues, dowels, and string, have students design, build and present an architectural model for a new community based on a given problem statement. Possible design considerations could include climate, natural resources, geographical features, and culture. Each model and presentation should account for things like recreation, transportation, residential housing, commercial enterprises, industrial complexes, utilities systems, and community services. Ask students to explain how good planning, or the lack of it, has affected the quality of life in their own community.

20. Discuss how construction sites, materials, techniques, and processes might be different in the future. Using materials like cardboard, paper plates, styrofoam cups, drinking straws, and glue, have a group of students design, build and present models describing cities of the future. Possible sites for the futuristic communities could be on the ocean, under water, in space, underground, on the moon, and/or on another planet. Models and presentations should describe the facilities for things like producing food, products, and structures; transporting people and goods; communication information; providing and utilizing energy; recreation and entertainment; and waste disposal. Discuss how location influences how people design and construct buildings and structures. Ask students to forecast how new style buildings might affect the way we live, work and play in the future.

21. Discuss the milestones in the history and evolution of construction technology. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

MANUFACTURING SYSTEMS

Suggested Learning Objectives

Upon completion of the manufacturing systems unit, students will be able to:

A. Define and properly use common manufacturing **terminology** like automation, just-in-time manufacturing, statistical quality control, participatory management, group technology, and computer integrated manufacturing.

B. Identify basic **applications** for manufacturing technology including things like building automobiles, making electronic components, and producing food products.

C. Identify basic natural, human, material, financial, technological, and informational **resources** used in manufacturing processes and enterprises.

D. Describe the major **processes** used in the manufacturing products, including researching, developing, designing, engineering, planning, tooling, scheduling, expediting, selling, and distributing.

E. Describe the social and environmental **impacts** associated with manufacturing activities including displacement of workers, quality of work life, air and water pollution, waste disposal, and enhancing the quality of life. SC2

F. Describe the major milestones in the **history** and evolution of manufacturing including the establishment of cottage industries; introduction of interchangeable parts and Henry Ford's assembly line technique; and the development of computer-aided manufacturing processes. SS2

G. Identify and evaluate **career** opportunities in manufacturing (e.g., quality control technician, designer, industrial engineering) based on interests, talents, and career expectations.

H. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when around or participating in manufacturing activities. PH3

I. Describe the role of research, development, and engineering in the manufacturing systems including identifying problems, gathering information, developing preliminary designs, selecting and refining designs, specifying designs, building and testing prototypes, and presenting designs to management.

J. Describe the role of industrial relationships within a manufacturing enterprise including maintaining communications; safety standards; and labor, public, and government relations.

K. Describe the role of marketing in the manufacturing system including market research, packaging goods, selling products, and distributing finished goods.

L. Evaluate custom, intermittent, and continuous manufacturing techniques for a given product based on equipment, human resources, materials, cost, quantity, and time considerations.

M. Apply basic mathematical concepts to do things like calculate profit, determine statistical quality control, estimate materials, and compile market research data. MA1

N. Describe and forecast the implications of innovative manufacturing technologies like CAD, CAM, JIT, CIM, DNC, AGV, ASRS, and FMS on a manufacturer's work force, profit potential, product quality, efficiency, and competitiveness. SC2

O. Establish a student enterprise that has an identity, has an organizational structure, researches and develops a product, designs and implements a product system, markets the product, and handles financial affairs. SS1

P. Use common tools, materials, and techniques to perform manufacturing processes like making mock-ups, fabricating simple jigs and fixtures, and packaging products. PH6

Q. Discriminate between pure and applied research; custom, intermittent, and continuous manufacturing techniques; and proprietorships, partnerships, and corporations.

Suggested Learning Experiences

1. Introduce students to establishing a manufacturing enterprise. Using traditional graphics and computer-aided design tools, have each student identify, design, and propose a name and logo for their student enterprise. Ask students to evaluate each proposal and select the best five. Using criteria like appearance, readability, and appropriateness, have students select the best proposal. Discuss the importance of a strong company identity and how it affects profit. Have the students compare their logo design with those of other companies in their community.

2. Introduce students to the management structures used to organize manufacturing enterprises. Using materials like poster board, computer-aided graphics, and/or large sheets of paper, have students develop an organizational chart for their student enterprise. Include and fill positions for corporate officers, managers, and/or workers. Have the students discuss how the division of labor affects communication, efficiency, and profit in a manufacturing enterprise.

3. Discuss how enterprises raise capital to finance their manufacturing process. Using traditional and computer-aided graphic arts tools, have the students design and reproduce a stock certificate. Have students sell the stock to raise money for their student enterprise. The stock certificates should include things like the name of the company, the date of sale, the number of shares represented, an identification number, the value of the stock, and the president and secretary signatures (e.g., vice president of finance). Have the

students compare the advantages and disadvantages of raising money through the sale of stock, use of personal capital, and securing loans.

4. Explain the relationship between labor and management within manufacturing enterprises. Using democratic procedures, have the students nominate and elect a union president and shop steward. Have representatives from labor and management develop, negotiate, vote on, and ratify a labor contract. The final contract should define things like safety policies, labor benefits, job descriptions, grievance procedures, and management responsibilities. Have students discuss the effects of good versus poor labor relations on things like morale, product quality, working conditions, productivity, and profit.

5. Discuss how products are often designed and manufactured to solve problems. Divide the class into research and development teams. Ask each team to identify and write a problem statement that requires a product for its solution. An example problem statement could be: Design a device that organizes articles commonly stored in a school locker (e.g., pens, pencils, paperbacks, calculators). Discuss how products are designed to address a specific problem or fulfill a need or want.

6. Introduce students to a variety of preliminary design techniques. Have each R & D team brainstorm possible solutions to the problems identified during the activity above. Have students draw thumbnail sketches for each design idea. When students have finished their thumbnail sketch, have them develop a rough sketch that identifies and/or combines their best design ideas. Ask students to explain why designers sketch their ideas before they draft the plans or make the product. Discuss the cost-effectiveness of preliminary sketches early in the design process.

7. Show students the two and three dimensional techniques used to refine product designs. Using their rough sketch as a guide, have each R & D team draw a rendering of their product using colored pencils, markers, or chalk and make a three dimensional mock-up using easy-to-work materials like styrofoam, clay, cardboard, or wood. Have each team evaluate their rendering and three dimensional mock-up based on design considerations like appearance, consumer demand, profit potential, ease of manufacturing, and safety. Ask students to evaluate the advantages and disadvantages of two versus three dimensional representations of a product design.

8. Introduce students to the concept of specifying a product design. Using traditional and/or computer-aided drafting/design tools, have each R & D team prepare a set of working drawings. Their working drawings should include things like multi-view drawings, assembly drawings, specifications, and a bill of materials. Have the students explain how working drawings can affect the final product's quality, safety, assembly, serviceability, and profit potential.

9. Introduce the students to the concept of market research. Based on their product's design, have each R & D team develop and conduct a market survey. Their survey questionnaire should include items

about the respondent's age, gender, and occupation, the price for the product, how the product could be used, the appearance of the product, how the product competes with similar products on the market, and how the product can be improved. Have students explain how the information gathered through market research can influence design, marketing, and manufacturing decisions.

10. Discuss the importance of prototypes in the product development process. Using basic building materials like wood, plastic, metal, and fasteners, have each group of students build, test, and evaluate a full scale working prototype. Each prototype should be evaluated on things like safety, function, design, cost, durability, ease of servicing, and ease of manufacturing. Have students explain how testing and evaluating prototypes may affect safety, efficiency and profit.

11. Discuss the steps involved with preparing and presenting a product proposal. Using plans and specifications, mock-ups, renderings, prototypes, market research data, and presentation media, have each R & D team prepare and present a proposal for the product to be manufactured by the class. Each proposal and presentation should include information on marketing, financing, and manufacturing the product. Ask students to evaluate and select the best proposal based on design considerations like safety, function, appearance, cost, durability, and the ease of manufacturing and servicing. Have the students explain the importance of evaluating each proposal before selecting and manufacturing a new product.

12. Show students the techniques used to analyze a product and design a production system. Using the prototype as a guide, have students representing the production department develop a flow chart for each component and an operation chart for manufacturing the product. The charts should illustrate things like operations, inspections, transportation, delays, and storage functions. Ask students to explain how production charts can be used to design tooling, facilities, material handling systems, and quality control procedures.

13. Introduce students to the concept of plant layout. Using equipment templates and floor plans or computer-aided drafting/design systems, have students from the production department design a plant layout for their manufacturing enterprise. Design considerations for the plant layout should include things like the space needed for production; the production sequence; the location of machine, work stations and material handling devices; and the storage space needed for raw materials and finished goods. Use the final plant layout to set up a manufacturing facility. Have the students discuss how plant layout can affect a product's final selling price.

14. Introduce students to the devices used to move materials, assemblies, and finished products during the production process. Using materials and equipment like wood, metal, plastic, cardboard, rollers, fabric, motors, and robots, have a group of students design, build, test, and maintain a materials handling system. The materials handling system could feature devices like conveyers, robots, carts, chutes, rollers, and/or pneumatic tubes. Have the students discuss

the applications, advantages, and disadvantages of various material handling devices.

15. Discuss the technology used to tool a manufacturing facility. Using basic building materials and fasteners, have students from the production department design, build, and test tooling for their production system. Depending on the product, the tooling could include things like jigs, fixtures, templates, molds, and dies. Ask students to evaluate their tooling devices in terms of design, accuracy, safety, and durability. Discuss how tooling can influence things like set-up time, material processing time, quality control, and plant efficiency.

16. Discuss the role automation is playing in modern manufacturing processes. Include technologies like CAD, CAM, CNC, DNC, CIM, and FMS in your discussion. Have small groups of students program a real or simulated computer numerical control (CNC) lathe, drilling, or milling machine to produce a simple object from a given piece of standard stock. Have students debate the pros and cons associated with automation from the management, labor, and consumer point of view.

17. Show students the techniques used to ensure product quality. Have students from the production department develop a system for maintaining quality before, during and after the manufacturing process. Ask students to design, develop, and test check lists and gauges for inspecting materials, components, assemblies and finished products. Ask students to discuss how techniques like statistical analysis and quality circles can be used to improve product quality and employee morale.

18. Introduce students to the concept of statistical process and quality control. Have students from the production department measure and record a critical dimension of a sample of components using a micrometer, vernier, and/or calibers. Using a teacher-prepared form, have students determine the mean, range, and/or standard deviation for the critical dimension. Compare the results with the specifics defined in the working drawing. Use the results to make decisions about tooling adjustments, cutting speeds, and feed rate. Ask students to explain the importance of being able to make informed quality control decisions in today's sophisticated manufacturing processes.

19. Explain how manufacturing companies establish and maintain safety standards. Using a teacher-prepared check list, have a group of students conduct a safety inspection to identify potential safety hazards and develop strategies to ensure safety. The check list should include items about personal, hand tool, machines, equipment, and general safety. Use the information collected to establish a list of safety rules for the student enterprise and to promote safety with posters, slogans, and incentives. Have the students discuss and compare their inspection list with one from OSHA. Discuss the importance of safety in the workplace from a company and worker perspective.

20. Explain the importance of timing when designing and implementing a manufacturing system. Using things like stop watches and a

teacher-prepared instrument, have students from the production department conduct time and motion studies to design and develop workstations. Use the data collected to train workers, refine tooling, adjust materials-handling systems, and improve quality control procedures. The goal should be to develop a just-in-time production system. Discuss the role just-in-time technology plays in helping American companies be competitive in a world economy.

21. Discuss the importance of testing the manufacturing process before full scale production begins. After setting up a manufacturing facility, have the students conduct a pilot run and manufacture two or three products. During the pilot run, have students identify and debug problems throughout the system. Students should look for things like overloading electrical circuits, products backing up, insufficient material handling devices, and unsafe working conditions. Ask the students to discuss how pilot runs can be used to improve things like safety, efficiency, and profit.

22. Introduce students to the concept of packaging finished goods. Discuss and show examples of various types of packaging techniques. Using tools and materials like plastic bags, poster board, dry transfer type, markers and/or electronic publishing, have students from the marketing department design and produce packaging for their products. The final packaging should protect and display the product, make the product easier to handle, attract potential consumers, and provide information about the product. Discuss the communication role of packaging in the sales and distribution process and how it can affect product appearance, cost, and sales.

23. Discuss the techniques used to promote the sale of manufactured products. Using tools and materials like video taping equipment, audio recording equipment, electronic publishing equipment, poster board, stencils, and markers, have students from the marketing department design, produce, and display advertisements for their student enterprise. Students should include techniques like announcements over the PA system, television commercials, displays, fliers, brochures, and/or posters to advertise their product. The final advertisement should attract the consumer's attention, inform the consumer about the product and the company, and persuade the consumer to purchase the product. Ask the students to discuss the advantages and disadvantages of using television and radio commercials; newspaper and magazine ads; and billboard and bus displays to advertise products. Discuss the ethical issue surrounding truth in advertising.

24. Describe the sales strategies and the distribution chains used to move products from the manufacturer to the consumer. Have students from the marketing department develop and implement a sales and distribution system for their product. Address issues like who is going to sell the product; when and where will sales be conducted; how to handle and document the exchange of money; and how and when will the product be delivered to consumers. Have students discuss the ethical, interpersonal, and legal issues associated with selling products.

25. Introduce students to concepts of closing an enterprise. Using the financial records from each department, have students from the finance department determine the cost associated with producing the product (e.g., labor, materials, overhead). Using cost and income figures, calculate the company's financial condition. If the company has made a profit, figure the size of each stockholder's dividend. Along with financial information, have each department develop and present an annual report to a real or fictitious board of directors (e.g., school counselors, administrators, board members, and teachers). Send a copy of the annual report to each stockholder with their dividend. After the company has been dissolved, ask students to explain the relationship between risks and rewards in the free enterprises. Discuss ethical issues surrounding free enterprise.

26. Discuss the milestones in the history and evolution of manufacturing systems. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

27. Discuss the career opportunities in manufacturing systems. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to manufacturing systems. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

Suggested Learning Objectives

Upon completion of the servicing unit, students will be able to:

A. Identify basic **applications** for servicing technology including installing systems; repairing mechanical and electric components; and maintaining consumer and industrial products.

B. Define and properly use common servicing **terminology** like estimate, bid, installation, repair, product liability, troubleshoot, and work order.

C. Describe the basic servicing **processes** like installing, repairing, adjusting, modifying, replacing, salvaging, maintaining, diagnosing, and estimating.

D. Describe the social and environmental **impacts** associated with servicing activities including the recycling and disposing of defective components and products; the trend toward a service-based economy; and consumer fraud. SC2

E. Describe the basic human, material, natural, informational, financial, and technological **resources** associated with servicing processes and enterprises (e.g., test equipment, product specifications, transportation).

F. Describe the major milestones in the **history** and evolution of servicing technology including the introduction of trades, use of computerized troubleshooting technologies, and development of consumer protection agencies. SS2

G. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when around or participating in servicing activities. PH3

H. Identify, describe, and evaluate **career** opportunities in servicing (e.g., service technicians, industrial trouble shooters, and carpet installers) based on their interests, talents, and career expectations.

I. Describe the basic attributes of service organizations such as: work performed close to the customer, workers do not produce a product, service cannot be stored, customers pay mostly for labor, and companies tend to be small.

J. Discriminate between industrial service and personal service.

K. Determine the tools, materials, and processes needed to address a given servicing problem.

L. Use common problem solving techniques to troubleshoot and service a simple mechanical, electrical, fluid power, and/or thermal system.

M. Determine the best solution to a servicing problem based on cost, safety, material, consumer, labor, liability, and ethical considerations.

N. Describe the communication considerations associated with servicing activities including providing accurate estimates, answering service calls, documenting the services rendered, and billing customers.

O. Analyze the ethical issue associated with servicing activities including liability, consumer protection, and warranties.

P. Forecast the potential effects of a service-based economy on things like unemployment, small businesses, and international trade. SS1

Suggested Learning Experiences

1. Introduce students to the concept of servicing mechanical devices. Using common commercial or teacher-prepared service manuals, have a small group of students troubleshoot a small engine. Possible teacher-installed bugs could include things like defective spark plugs, broken head gaskets, closed needle valves, and/or clogged fuel lines. Using a real or teacher-made work order, have students document the work performed, labor costs, part costs, and total cost of servicing their assigned engine. Ask the students how preventive maintenance can prolong machine and equipment life. Discuss the importance of documenting services and their cost.
2. Discuss the communication tools used to describe or illustrate the procedures used to service various products. Have small groups of students analyze a simple electrical device and develop a flow chart and/or service manual for troubleshooting and servicing the circuit. Make sure the flow charts or service manuals feature procedures for diagnosing and replacing things like defective wires, switches, bulbs, and/or batteries. Ask students to evaluate the advantages and disadvantages of using graphic versus written procedures when servicing a product.
3. Introduce the students to the concept of trouble shooting. Using common commercial or teacher-prepared service manuals, have small groups of students troubleshoot and service a microcomputer. Possible teacher-installed bugs could include things like removing the interface card, using defective software, adjusting the disk drive speed, installing defective cables, and/or altering monitor adjustments. Have students analyze the ethical issues associated with servicing consumer and industrial products.
4. Explain the difference between production and service organizations. Discuss the relationships between the two types of organizations and their customers, the types of work performed, and what the customer purchases. Establish a student enterprise that sells, installs, and services burglar alarms. Identify a name for the new company and appoint service managers and technicians. Ask students how the trend toward a service-based economy will affect their educational needs, career options, consumer practices, and quality of life.

5. Discuss the role and importance of training in service industries. While playing the role of a manufacturer's representative, conduct training sessions on installing, troubleshooting, and servicing simple alarm systems. Discuss how some occupations require service technicians to take a certification examination. Require students to take and pass a test on the content taught during the training sessions before they are allowed to participate in subsequent activities. Ask students to discuss why service industries need trained service technicians.

6. Discuss the practices used in the service industry to assess customers' needs and provide estimates. Provide each student a scenario describing the features a customer would like in their alarm system (e.g., panic switch, key locations, number of windows protected). Have each team report to a mock-up of a house featuring working doors and windows. Ask each team to determine the components needed to fulfill the customer's requirements. Using a teacher-developed form, have each team complete an estimate describing the work that needs to be performed, the materials required, and how much the project will cost. Discuss the consumer's right to an accurate estimate versus the service agency's need for flexibility in the event of unexpected expenses.

7. Introduce students to the concept of installation. Provide each service team a work order describing a given customer's needs based on the information gathered during the activity above. Using things like magnetic switches, pin switches, key switches, buzzers, and relays, have students install an alarm system onto their assigned mock-up. Make sure each alarm system works and is installed properly. Have each team complete and submit a bill for the services rendered. The bill should document the work performed, material used, labor costs, material costs, taxes, and total cost. Ask students to describe the consequences of not installing products correctly on a company's reputation, profit, customer relations, and future sales.

8. Provide each service team a work order for a service call. Each work order needs to describe the customer's complaint based on a teacher-installed bug. Possible bugs could include things like defective connections, wires, switches, batteries, and buzzers. Using the work order as a guide, have each service team identify the tools, materials, and replacement parts needed to service the alarm system. When they are ready, have each team report to the mock-up corresponding to the service call and service the alarm system so it works according to specifications. Have each team complete and submit a bill for the services rendered. Ask students to identify the characteristics of a professional service technician (e.g., appearance, skills, courtesy).

9. Discuss the milestones in the history and evolution of servicing. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe

how given events influenced our culture and subsequent technological developments.

10. Discuss the career opportunities in servicing systems. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to servicing systems. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

Addresses

The following list of addresses is provided for teachers desiring additional information:

Illinois Vocational Curriculum Center (IVCC)
Sangamon State University F-2
Springfield, IL 62708
800/252-8533

American Vocational Association (AVA)
828 South 2nd Street
Room 403
Springfield, IL 62704
217/433-0815

Curriculum Publications Clearinghouse
Western Illinois University
Horrabin Hall 46
Macomb, IL 61455
800/322-3905

Center for Implementing Technology Education
Department of Industry & Technology
Ball State University
Muncie, IN 47306

Technology Student Association (TSA)
University of Illinois
Department of Vocational & Technical Education
1310 S. Sixth Street
Champaign, IL 61820

Illinois Vocational Association (IVA)
44 Emporia Avenue
Springfield, IL 62702

American Technology Student Association (ATSA)
1908 Association Drive
Reston, VA 22091
703/860-9000

International Technology Education Association (ITEA)
1914 Association Drive
Reston, VA 22091

Illinois Industrial Technology Education Association (IITEA)
44 Emporia Avenue
Springfield, IL 62702

Department of Adult, Vocational and Technical Education
Program Improvement Section
100 North First Street
Springfield, IL 62777

Society of Manufacturing Engineers
One SME Drive, P. O. Box 930
Dearborn, MI 48121

National Association of Home Builders
15th & M Street, N.W.
Washington, DC 20005

Carol Henry
Mix Coordinator
Gregg Division - McGraw Hill Book Company
New York, NY 10020
(314) 256-2222
The Technology Link

Software

The following partial list of software is offered to help teachers identify programs having potential for application in technology courses:

SURVEYS UNLIMITED
Mindscape Inc.
3444 Dundee Road
North Brook, IL 60062

ROBCAT
Computer Applications Tomorrow
P. O. Box 4093
Carlsbad, CA 92008

GEARS: STRATEGIES IN PROBLEM-SOLVING
PROFESSIONAL SIGN MAKER
THE FACTORY
Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570

BANK STREET WRITER
Broderbund Software
17 Paul Drive
San Rafael, CA 94903

CADDRAW
Kitchen Sink Software
903 Knebworth Ct.
Westerville, OH 43081

SPRINGBOARD PUBLISHER
GRAPHICS EXPANDER
CERTIFICATE MAKER
Springboard Software, Inc.
7807 Greekridge Circle
Minneapolis, MN 55438

QUICK DRAFT
Interactive Microware, Inc.
P. O. Box 139
State College, PA 16804

DISCOVER CAD
Hearlihy & Co.
714 W. Columbia Street
Springfield, OH 45501

CONSTRUCTION ESTIMATOR
Mesa Research, Inc.
Rt. 1, Box 1456A
Waco, TX 76710

CUBE BUILDER
Human Relations Media
175 Tompkins Avenue
Pleasantville, NY 10570-9973

AUTOSKETCH
AUTOCAD
Autodesk, Inc.
2320 Marinship Way
Sausalito, CA 94965

SPACE M+A+X
Final Frontier Software
18307 Burbank Blvd., Suite 108
Tarzana, CA 91356

THE GRAPHICS DEPARTMENT
Sensible Software, Inc.
210 S. Woodward, Suite 229
Birmingham, MI 48011

ROBOT ODYSSEY I
The Learning Company
545 Middlefield Road
Suite 170
Menlo Park, CA 94025

CNC
Extension Instruction and Materials Center
Division of Continuing Education
University of Texas at Austin
Austin, TX 78758

Books

The following textbooks will contain information that will help teachers prepare to teach technology courses:

Bailey, O., Pickup, R., Lewis, R., & Patient, P. (1981). *Modular courses in technology: Mechanics.* Edinburgh: Oliver & Boyd.

Bame, E. A., & Cummings, P. (2nd. ed.). (1980). *Exploring technology.* Worcester: Davis.

Blundell, A., Hawkins, R., Luddington, D., Douglas, I., Harrison, G., Ive, M. (1981). *Modular courses in technology: Structures.* Edinburgh: Oliver & Boyd.

Deane, Q. (Ed.). (1982). *How it works.* New York: Grenwich House.

Fales, J. F., Kuetemeyer, V. F., Brusic, S. K. (1988). *Technology: Today and tomorrow.* Mission Hills, CA: Glencoe.

Fales, J. F., Sheets, E. G., Mervich, G. J., & Dinan, J. F. (1986). *Manufacturing: A basic text.* Peoria: Bennett & McKnight.

Feirer, J. L., & Lindbeck. J. R. (1986). *Production Technology: Industry today and tomorrow.* Peoria: Bennett & McKnight.

Feldman, A., & Gunston, B. (1980). *Technology at work.* New York: Facts on File.

Goetsch, D. L., & Nelson, J. A. (1987). *Technology and you.* Albany: Delmar.

Hacker, M., & Barden, R. A. (1988). *Living with technology.* Albany: Delmar.

Hacker, M., & Barden, R. A. (1987). *Technology in your world.* Albany: Delmar.

Harms, H. (Ed.). (1988). *Construction technology activities.* Albany: Delmar.

Harms, H. (Ed.). (1988). *Manufacturing technology activities.* Albany: Delmar.

Harpur, P. (Ed.). (1982). *The timetable of technology.* New York: Hearst.

Henak, R. M. (1985). *Exploring Construction.* South Holland, IL: Goodheart-Willcox.

Huth, M. W. (1989). *Construction technology.* Albany: Delmar.

Kazanas, H. C., Klein, R. S., & Lindbeck, J. R. (1974). *Technology of industrial materials.* Peoria: Bennett

Kingston, J., & Lockwood, A. (1985). *How bridges are made.* New York: Facts On File.

Lindbeck. J. R., & Kruppa, J. R. (1984). *Basic manufacturing.* Mission Hills: Glencoe.

Lux, D. G., Ray, W. E., Blankenbaker, E. K., & Umstattd, W. (1982). *World of construction.* Bloomington: McKnight.

McShea, J., Byrne, D., Danks, K., Hewitt, T., & Wooley, N. (1981). *Modular courses in technology: Materials technology.* Edinburgh: Oliver & Boyd.

Minton, G. D., & Minton, B. K. (1987). *Teaching technology to children.* Worcester: Davis.

Page, R., Clarke, R., & Poole, J. (1982) *Modular courses in technology: Problem solving.* Edinburgh: Oliver & Boyd.

Taylor, P. (1982). *The kids' whole future catalog.* New York: Random House.

Todd, R., McCrory, D., & Todd, K. (1985). *Understanding and using technology.* Worcester: Davis.

Williams, C. F., Badrkhan, K. S., & Daggett, W. R. (1985). *Technology for tomorrow.* Cincinnati: South Western.

Williams, C. F., Badrkhan, K. S., & Daggett, W. R. (1985). *Technology at work.* Cincinnati: South Western.

Wright, R. T. (1985). *Exploring manufacturing.* South Holland, IL: Goodheart-Willcox.

Wright R. T. (1984). *Manufacturing: Material processing, management, careers.* South Holland: Goodheart-Willcox.

Wright, R. T. (1987). *Process of manufacturing.* South Holland: Goodheart-Willcox.

Wright, R. T., & Henak, R. M. (1985). *Exploring production.* South Holland: Goodheart-Willcox.

Wright, R. T., & Jensen, T. R. (1984). *Manufacturing: Material processing, management, careers.* South Holland: Goodheart- Willcox.

Manuals

Manuals available from the Curriculum Publications Clearinghouse, Western Illinois University, Horrabin Hall 46, Macomb, IL 61455, 800/322-3905:

- Stråtegies for Problem Solving
- Transition Training: Manual for Personal Growth, Development and Self-Improvement
- The Vocational Ethics Manual
- Generalizable Communications Skills Assessment: User Manual
- Generalizable Communications Skills Assessment: Resource Directory
- Generalizable Interpersonal Skills Assessment: User Manual

- Generalizable Interpersonal Skills Assessment: Resource Directory
- Generalizable Mathematics Skills Assessment: User Manual
- Generalizable Mathematics Skills Assessment: Resource Directory
- Generalizable Reasoning Skills: User Manual
- Generalizable Reasoning Skills: Resource Directory

Transportation Technology Curriculum Guide

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TRANSPORTATION TECHNOLOGY

Course Rationale

Transportation, as we know it today, is considerably different than generations ago. The means by which people and goods are moved have evolved from slow moving humans and animal powered systems to sophisticated multi-purpose space shuttles. It seems as though humans constantly demand greater speed, efficiency, comfort, and safety in their vehicles. This has caused constant change and innovation in the way we guide, control, propel, and support our transportation systems.

Transportation is an important aspect of our society. People depend on the fact that there are choices available when they need to move themselves, others, or goods from one location to another. Many times, these choices are taken for granted. Our society takes for granted that they can be moved at will with random mode vehicles like cars, ships, and planes, as well as fixed route systems like trains, elevators, and escalators. We take for granted that pipelines will bring us water, provide natural gas, and dispose of sewage. This attitude has made our society quite dependent on transportation systems.

Because of this dependency, it is imperative that transportation technology be included in a student's educational experience, especially since 9th and 10th graders are becoming more active in the transportation system. Until this time in their lives, they have been primarily passengers rather than transporters. It is important that students understand that factors like quality, cost, space, efficiency, comfort, safety, and speed must be considered when selecting an appropriate mode of transportation. Studying Transportation Technology will place students in a better position to select the transportation system that will be most efficient, economical, and have the least detrimental impact on the environment.

Course Mission

The purpose of the Transportation Technology course is to orient students to the basic resources, technical processes, industrial applications, and technological impacts related to land, water, air, space, and materials-handling transportation systems. The course will help students to:

- use and understand the verbal and symbolic language used to describe transportation systems and phenomenon;
- develop and present creative solutions to present and future transportation problem;
- identify and investigate potential career opportunities in the area of transportation;

- understand the evolution of transportation technology and its influence on our culture; and
- safely use common tools, materials and processes to design, build, and test transportation systems.

Course Description

The Transportation Technology course includes units of land, water, air, space, and materials-handling transportation. Each unit will involve students in a wide variety of learning activities and experiences including things like designing an aerodynamic vehicle, building a submarine, evaluating wing designs, testing rockets for stability, and programming a pick-and-place robot.

Course Outline

In the spirit of orientation, students should be introduced to a wide range of transportation technologies. The following course outline lists the recommended units for either a nine or an eighteen week format. Potential lesson topics are provided under each unit title. Each lesson should embrace as many of the unit objectives as possible. In a nine week format, an emphasis should be placed on the terminology, resources, processes, applications, impacts, careers and safety concepts that relate to the lesson topics.

Sample Transportation Technology Course Content Outline

I. Introduction to Transportation Technology

II. Land Transportation
    A. Highway
    B. Off-road
    C. Rail
    D. Mass transit
    E. Support systems

III. Materials-handling
    A. Fixed systems
    B. Variable systems
    C. Robotic
    D. Pipeline

IV. Water Transportation
    A. Boats
    B. Surface effect ships (i.e., hovercrafts, hydrofoils)
    C. Displacement ships
    D. Submersibles
    E. Support systems

V. Air Transportation
    A. Lighter-than-air
    B. Fixed winged
    C. Rotary-winged
    D. Support systems

VI. Space Transportation
    A. Unmanned
    B. Manned
    C. Support system

Adapting the Transportation Technology Course Outline to Nine or Eighteen Week Formats

Hands-on learning activities are one of the most powerful ways of helping students learn about technology. Unfortunately, they are very time consuming. The following strategies can be employed to use available laboratory time more efficiently without sacrificing important unit objectives:

- Divide the class into small groups and assign each group a different learning activity related to the lesson topic. When each group has finished their assigned activities, have students present their experiences to the rest of the class. For example, during the materials-handling unit, have each group design, build, test, and present either a fixed path, variable path, pipeline, or robotic material handling system.
- Avoid assigning complex laboratory activities when simpler activities will enable students to experience important concepts and achieve the desired objectives. For example, during the land transportation unit, have students make and test wind tunnel mock-ups for an aerodynamic vehicle out of clay instead of wood.
- Prepare work stations that organize the tools and materials needed to conduct laboratory activities prior to class. For example, during the space transportation unit, develop rocket kits that students can assemble and test.
- Have students experience a wide range of concepts through one or two robust learning activities. For example, during the air transportation unit, have students design, build, and test a glider. Discuss how the basic parts of an air transportation system (i.e., propulsion, control, guidance, payload, supports) transfer to other lighter-than-air, fixed winged, and rotary winged aircraft.

During an eighteen week format, students can engage in more complex learning activities and experiences, given topics in greater depth. In addition, there is an opportunity to provide a wider range of learning experiences. The study of technology allows for an infinite number of learning experiences. Therefore, it is important to select and implement learning activities in an efficient manner.

INTRODUCTION TO TRANSPORTATION TECHNOLOGY

Suggested Learning Objectives

Upon completion of the Introduction to Transportation Technology unit, students will be able to:

A. Define and properly use common transportation technology terminology like combustion, pathways, velocity, vehicle, mode, payload, and terminal.

B. Categorize modes of transportation such as land, water, space, air or materials handling transportation systems.

C. Categorize transportation systems such as fixed or variable path transportation systems.

D. Categorize turbines, four cycle, diesel, Wankel, Sterling, and steam engines as internal or external combustion engines.

E. Describe the propulsion, control, guidance, payload, and support systems for various land, water, space, air and materials handling systems.

F. Describe the basic applications for transportation technology including moving people, transporting goods, and facilitating recreation.

Suggested Learning Experiences

1. Explain how transportation systems have control, propulsion, payload, guidance, and support subsystems. Using materials like balloons, clothes pins, straws, paper clips, straight pins, fishing line, and masking tape, have students design, build and test a vehicle that will carry a payload a significant distance (15 to 25 feet). Ask the students to describe the control, propulsion, and guidance subsystems on their transportation system and compare them to those used on real transportation systems.

2. Introduce students to a variety of transportation systems. Include things like bicycles, trains, barges, super tankers, commercial aircraft, helicopters, rockets, space shuttles, pipelines, conveyers, and robots. Assign each student a topic and ask them to develop a display describing a mode of transportation. Each display should identify if the transportation system is a land, water, air, space, or materials-handling system and is fixed or a variable path system. In addition, each display should describe the transportation system's propulsion, control, guidance, payload, and support subsystem.

LAND TRANSPORTATION SYSTEMS

Suggested Learning Objectives

Upon completion of the land transportation unit, students will be able to:

A. Define and properly use common land transportation **terminology** like payload, combustion, suspension, containerization, and mode.

B. Describe the **processes** used in land transportation like routing, dispatching, steering, directing, switching, towing, hauling, scheduling, loading, unloading, and fueling.

C. Identify the basic natural, human, material, financial, technological, and informational **resources** used in land transportation processes and enterprises (e.g., petroleum products, drivers, pathways, maps).

D. Identify basic **applications** for land transportation systems including transporting people and goods, and recreation.

E. Identify the milestones in the **history** and evolution of land transportation technology including the development of the wheel, James Watt's steam engine, Henry Ford's Model T, and the French TGV super train. SS2

F. Identify and evaluate **career** opportunities in land transportation (e.g., truck dispatcher, civil engineer, topographer) based on their interests, talents and career expectations.

G. Describe the environmental and societal **impacts** associated with various land transportation technologies including urban sprawl, air pollution, land utilization, accidents, and noise. SC2

H. Identify the **safety** considerations and adhere to the safety practices associated with various modes of land transportation. PH3

I. Identify basic modes of land transportation including bicycles, trains, buses, automobiles, motorcycles, and trucks.

J. Identify and describe the basic systems within an internal combustion engine including the mechanical, lubrication, fuel, cooling, and ignition systems.

K. Describe the basic payload, guidance, propulsion, control, and support systems for a given mode of land transportation.

L. State the concepts, vehicles, support systems, and techniques used in intermodal transportation and how containerization saves time, money, and energy.

M. Determine the optimum means of transporting a given payload based on departure, destination, cost, time, energy, safety, and environmental considerations.

N. Design, build, test, and evaluate a transportation system that addresses a transportation problem based on cost, time, energy, environmental, and/or societal considerations.

O. Apply basic mathematical concepts to do things like determining a vehicle's speed, calculating energy utilization, and comparing vehicle specifications. MA1

P. Conserve energy, reduce congestion, and minimize waste by utilizing appropriate transportation technologies to transport people and goods from one location to another.

Q. Forecast the potential effects of America's dependance on automobiles and trucks on energy utilization, air pollution, transportation costs, and urban congestion.

Suggested Learning Experiences

1. Introduce students to the payload, guidance, propulsion, and control systems used in automobiles. Have students design, build and test a model car powered by a CO_2 cartridge, spring, or electric motor. Determine the relationships between aerodynamics, vehicle weight, energy used, and speed. Ask students to describe how they addressed current and future trends in automobile design when they designed their model.
2. Explain how automotive engineers, designers, and technologists solve problems by developing experimental vehicles. Provide students materials and components like pipe, wheels, sprockets, and chain. Have students design, build, and test an experimental energy efficient vehicle that is powered by a gasoline engine, an electric motor or a human. Calculate the amount of energy required to propel the vehicle a given distance. Discuss the aerodynamic, structural, payload, and propulsion variables that make land transportation vehicles more energy efficient.
3. Discuss the importance of aerodynamics when designing land transportation vehicles. Have students design and make mock-ups for futuristic automobiles, trucks, and trains. Use a commercial or constructed wind tunnel to test and evaluate each mock-up. Compare test results and mock-up designs to identify the characteristics of an aerodynamic vehicle. Ask students to evaluate aerodynamic features on photographs of up-to-date automobiles, trucks, and trains.
4. Discuss the need for public transportation in urban areas. Provide teams of students large simple maps featuring residential, commercial, and industrial areas and a problem statement describing how many people need to be transported from location to location at various times of the day. Have students build and present models describing a public transportation system using a car pool, commuter rail, personal rapid transit, or bus system. Make sure each presentation addresses cost, energy, societal, and environmental considerations. Ask students to evaluate the advantages and disadvantages of using multi versus single passenger transportation technologies.
5. Invite a professional truck driver to talk to your class about transporting goods by truck. Have the speaker address payload, weight, inspection, legal, maintenance, fuel, insurance, cost, and safety considerations associated with transporting goods by truck.

6. Discuss the structural techniques used to build bridges for various applications. Include concepts like load, span, tension, compression, suspension, cantilever, arch, and truss. Provide students a problem statement describing the specifications for making model bridges (i.e., length, width and height). Using easy-to-work materials, have students design and build a small model bridge. Place each bridge in a fixture and suspend a load from a given point on each structure. Increase the load until the bridge breaks. Have students analyze how each bridge carried and transferred the load and why it failed. Ask students to discuss the bridge they think has the best design features.
7. Introduce students to the super trains used in Japan, France, and the United States and discuss what makes them an innovative form of transportation. Using common and easy-to-work materials, have teams of students design, build and present a working model for a rail system based on MAGLEV, tracked air cushion, monorail, or evacuated tube technologies. Have students identify and discuss the practical and technological problems associated with super train technology.
8. After introducing the internal combustion engine, have teams of students disassemble and inspect an automobile or small engine. Have students analyze how the mechanical, ignition, fuel, cooling, and lubrication systems work together to convert chemical energy into mechanical energy. Discuss how each of the basic systems identified apply to other types of engines used on land transportation vehicles. How could the transportation systems we use today influence the systems ten years from now?
9. Discuss the safety features and devices used in new automobiles. Provide students a simple vehicle that will carry an egg down a ramp. Have students use things like weather stripping, rubber bands, springs and balloons to modify the vehicle so it can travel down a ramp and strike a rigid object three consecutive times without breaking the egg. Ask students to explain and assess how the strategies they used to protect the egg apply to things like air bags, seat belts, energy absorbing bumpers, and padded dash boards. Have students discuss and defend what safety features they consider most important in a car.
10. Discuss the milestones in the history and evolution of land transportation. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.
11. Discuss the career opportunities in land transportation systems. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to land transportation systems. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

MATERIALS-HANDLING SYSTEMS

Suggested Learning Objectives

Upon completion of the material-handling unit, students will be able to:

A. Define and properly use material-handling **terminology** like route, aggregation, teach pendant, distribution, controller, coordinate, and actuator.

B. Identify basic **applications** for materials-handling systems like distributing oil and natural gas, moving materials and products through manufacturing facilities, sorting mail, loading and unloading vehicles.

C. Describe the societal and environmental **impacts** associated with material-handling activities like improved efficiency, interference with wildlife migratory patterns, visual pollution, land utilization, and displaced workers. SC2

D. Describe the major **processes** used for transporting and handling goods like loading, unloading, storing, packing, protecting, shipping, conveying, palletizing, and lifting.

E. Describe the basic human, material, natural, informational, financial, and technological **resources** associated with material-handling processes and enterprises.

F. Identify, describe, and evaluate **career** opportunities related to material-handling (e.g., industrial engineer, robot technician, fork-lift operator) based on their interests, talents, and career expectations.

G. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when around or participating in material-handling activities. PH3

H. Describe the major milestones in the **history** and evolution of material-handling technology including the invention of the elevator, the introduction of fork-lifts, and the construction of the Alaskan pipeline. SS2

I. Describe the advantages, disadvantages and potential applications for various materials-handling systems like pipelines, pneumatic tubes, automated guided vehicles, robotics, and automated storage and retrieval systems. SC2

J. Discriminate between fixed path and variable path materials-handling systems.

K. Design, build, test, and evaluate a materials-handling system that addresses a material-handling problem based on environmental, financial, material, safety, and energy considerations.

L. Forecast the implications of automated materials-handling systems on things like safety, labor patterns, flexibility, efficiency, and worker qualifications. SC2

M. Select the tools, materials, and processes needed to address a given material-handling problem.

N. Determine the optimum means of transporting a given object within a facility based on transportation, process, cost, time, energy, and safety considerations.

O. Describe the basic payload, guidance, propulsion, control, and support systems for a given materials-handling system.

Suggested Learning Experiences

1. Discuss how materials like petroleum and natural gas can be transported by means of pipeline technology. Using materials like a windshield washer pump, rubber hose, aquarium valves, T-fittings, and three containers, have a small group of students design, build, and test a model pipeline for a fictitious petroleum company that needs to move oil from a well to several refineries. Possible design considerations could include things like refinery capacity, terrain, animal migration patterns, distribution points along the pipeline and pipeline length. Have students analyze the advantages and disadvantages of pipeline technology versus other forms of transportation. Discuss the impact of pipeline technology on wildlife and the environment.

2. Introduce students to the concept of automated guided vehicles (AGV). Using materials like hobby motors, wheels, batteries, switches, wood, hardboard, and gears, have small groups of students design, build, and test an automated guided vehicle (AGV). When students have finished their AGV, place several numbered hardboard templates representing work cells in a flexible manufacturing system on the floor in a random order. Have each team write a program using simple English statements (pseudo code) describing the sequence of steps needed to navigate their AGV through the work cells. Have each team demonstrate their program to the rest of the class. Ask students to identify potential applications for AGV technology and describe the impact automated guided vehicles might have on employment, productivity, and competitiveness.

3. Discuss the various techniques used to move materials along a fixed path within a facility. Include things like chutes, elevators, augers, and conveyers (i.e., belt, roller, trolley, and bucket). Divide the class into teams and provide each team a problem statement. Possible problem statements could include things like moving components from one workstation to another, moving freshly painted parts through an oven, and moving products from one elevation to another. Using materials like motors, wood, PVC pipe, canvas, and rubber, have students design, build and test materials-handling systems. Design considerations should include things like speed, safety, accuracy, and dependability. Ask the students to

discuss how fixed path materials-handling systems shape production processes and worker behavior.

4. Discuss the various techniques used to move palletized materials. Include things like hand trucks, carts, fork-lifts, hoists, and cranes. Divide the class into teams and provide each team a problem statement. Possible problem statements could feature tasks like moving a batch of components from one workstation to another, loading and unloading a vehicle, and handling containers. Using materials like wheels, pulleys, and scrap material, have students design, build, and test functional or model variable path materials-handling systems. Ask students to compare and contrast the resources and applications used in fixed versus variable path materials-handling systems.

5. Discuss the role of robotics as a fixed yet flexible material-handling technology. Using materials and components like syringes, 1/8" plastic tubing, masonite, hobby motors, rubber bands, and switches, have small groups of students design, build, and test a simple pick-and-place robot that will move an assigned object from one location to another (e.g., washers, wooden blocks, ping pong balls). When students have finished their robots, have them write, test, and demonstrate a pseudo code program (English statements) describing the sequence of steps needed to move their assigned object. Have students explain how robotics free humans from dull, dirty, and dangerous types of work and how they extend human potential. Have students identify the impact of robotics on the qualifications needed to work in modern manufacturing companies.

6. Introduce students to the concept of teaching an industrial robot to perform a task. Discuss the various techniques used to teach industrial robots to perform tasks (e.g., teach pendant, walk through, programming). Using a computer simulated, table top, or mobile robot, have students teach a robot to perform a sequence of operations based on a problem. Potential problem statements could feature tasks like stacking objects, putting objects in a given order, placing objects in new locations upside down, follow a specific path, and/or place objects in containers. Ask students to compare the flexibility of robots to other forms of material-handling technology. Discuss how industrial robots affect some company's ability to compete within the United States and world markets.

7. Explain how materials can be moved on a cushion of air, thus reducing friction and drag. Using materials like a 4 foot plywood disk, 6 mil plastic, a shop vacuum, and duct tape, have small groups of students design, build, and test an air bearing material-handling device. During the testing process, have students take turns transporting each other on the air bearing. Ask students to determine the minimum pressure needed to lift the load that will move three bricks a distance of twenty feet. Have students identify and discuss the advantages, disadvantages, and potential application of air bearing devices.

8. Discuss the milestones in the history and evolution of materials-handling systems. Assign each student a historical event. Using library resources, have students gather information and develop an

abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

9. Discuss the career opportunities in materials-handling systems. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to materials-handling systems. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

WATER TRANSPORTATION SYSTEMS

Suggested Learning Objectives

Upon completion of the water transportation technology unit, students will be able to:

A. Define and properly use common water transportation **terminology** like berth, rigging, nautical mile, buoyancy, intracoastal, tonnage, waterway, bow, stern, port, dead reckoning, mariner's chart, and bearing.

B. Identify basic **applications** for water transportation technology like transporting people, providing recreation, and moving energy resources, raw materials, grain and products.

C. Identify basic natural, human, material, financial, technological, and informational **resources** used in water transportation processes, and enterprises.

D. Describe the social and environmental **impacts** associated with water transportation activities including water pollution, oil spills, and efficient transportation of bulk cargo. SC2

E. Describe the major milestones in the **history** and evolution of water transportation including the triumphs of the Spanish Armada, accomplishments of explorers like Columbus and La Salle, the Titanic disaster, construction of the Panama Canal, and the development of Japanese Shin Aitoku Mara. SS2

F. Identify, describe, and evaluate **career** opportunities related to water transportation technology (e.g., navigator, dock worker, merchant marine) based on their interests, talents, and career expectations.

G. Identify potential **safety** hazards, establish guidelines for safe behavior and adhere to common safety practices when around or participating in water transportation activities. PH3

H. Describe the major **processes** used in water transportation including shipping, exporting, importing, routing, docking, navigating, loading, unloading, towing, and trimming.

I. Describe and forecast the implications of innovative water transportation technologies like nuclear super tankers, air cushion crafts, hydrofoils, containerization, and LASH/Seabee vessels. SC2

J. Discriminate between boats and ships.

K. Describe the advantages, disadvantages, and potential applications for various water transportation systems like hydrofoils, barges, super tankers, and hovercraft. SC2

L. Evaluate water transportation systems like barges, tankers, jetfoil, and air cushion based on equipment, human resources, materials, cost, quantity, and time considerations.

M. Forecast the potential effects of innovative water transportation technologies on recreation, commuter transportation, water pollution, and international trade. SC2

N. Describe the basic payload, guidance, propulsion, control, and support systems for a given mode of water transportation.

O. Determine the optimum means of transporting a given payload based on departure, destination, cost, time, energy, safety, and environmental considerations.

Suggested Learning Experiences

1. Discuss the role of locks and dams on various waterways. Explain how they use technology to adjust for changing elevations on waterways. Using materials like Plexiglas, plastic hose, windshield washer pumps, and various fittings, have students in small groups design, build, test, and demonstrate a model lock and dam system that will transport a vessel from one elevation to another. Ask students to identify and evaluate the potential economic benefits and environmental impacts associated with building a lock and dam on a river.

2. Introduce students to the concept of buoyancy and how it applies to hull design and transporting a payload over water. Using tools and materials like polystyrene sheets, wooden molds, and a vacuum former, have students design, build and test a model barge that will transport a given cargo. Possible design considerations could include things like the depth of the waterway, the weight of the cargo, the cargo's volume, and the amount of material needed to make the barge. When students have finished testing and evaluating their model barges, have them describe the relationship between hull area, payload weight, and buoyancy. Discuss the advantages, disadvantages, and applications of barge technology as means of transporting cargo.

3. Discuss the various propulsion systems used to power small boats and large ships. Include wind, diesel, steam turbine, diesel/electric, turbine/electric, and nuclear propulsion systems in the discussion. Using materials like hobby motors, batteries, steel rods, and sheet metal, have students design, install, and test a propulsion system for the hulls developed during the activity above. Have students compare and contrast the types of propulsion systems used for recreational and commercial vessels. Discuss how energy, cargo, waterway, and hull considerations influence the type and size of the propulsion system.

4. Discuss the technologies used to control the velocity and direction of small boats and large ships. Using switches, variable resistors, and pieces of polystyrene plastic, have students design, install, and test control systems that enable their vessels to slow down, speed up and turn left or right. Have students identify the limitations of the control systems on large vehicles.

5. Discuss the role of wind energy in propelling recreational boats and commercial ships. Explain how various sail configurations harness the wind and propel boats and ships. Using tools and materials like polystyrene sheets, wooden molds, dowel rods, cloth, and vacuum formers, have students design and build model sailing vessels based on past, present, and/or future ship designs. Use portable fans and a large water container to test each design. Have students identify and describe the energy conservation and environmental advantages of using wind energy to propel boats and ships.

6. Explain how submarines and submersibles use air and water to submerge or surface. Have students connect a balloon to one end of a plastic hose and a squeeze bottle to the other end. Insert the balloon into a second plastic bottle and place in a tank of water. Allow the bottle to fill with water and sink to the bottom of the tank. Compress the squeeze bottle to inflate the balloon and cause the model to surface. Discuss how submersibles are used to conduct research and salvage work under water.

7. Discuss how hovercrafts are being used to transport people and goods across bodies of water. Explain how they travel over land and water on a cushion of air. Using materials like hobby motors, model airplane propellers, styrofoam, and plastic bags, have teams of students design, build, and test model hovercrafts. Ask each team to demonstrate and present their hovercraft to the rest of the class. Require presenters to identify and describe their hovercraft's propulsion, guidance, control, and payload systems.

8. Introduce students to the concept of a hydrofoil and how hydrofoil technology is being used to make ferry transportation faster and more comfortable. Using materials like Fiberglas, polyester resin, wood molds, and model rocket engines or two cycle hobby engines, have small groups of students design, build and test model hydrofoils that can travel across a body of water. Ask students to explain how hydrofoils reach high speeds by reducing drag.

9. Discuss the milestones in the history of water transportation technology. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

10. Discuss the career opportunities in water transportation technology. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to water transportation technology. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

AIR TRANSPORTATION SYSTEMS

Suggested Learning Objectives

Upon completion of the air transportation systems unit, students will be able to:

A. Define and properly use common air transportation **terminology** like radar, air traffic control, eddy current, fuselage, angle of attack, FAA, gates, airways, and instrument flight rules (IFR).

B. Identify basic **applications** for air transportation technology including carrying mail, shipping goods, providing recreation, and transporting people.

C. Identify basic natural, human, material, financial, technological, and informational **resources** used in air transportation processes and enterprises.

D. Describe the major **processes** used in transporting people and goods by means of air transportation including scheduling, planning, dispatching, navigating, controlling, landing, guiding, propelling, lifting, and thrusting.

E. Describe the social and environmental **impacts** associated with air transportation activities including air and sound pollution, land utilization, airport and air traffic congestion, rapid transportation, accidents. SC2

F. Describe the major milestones in the **history** and evolution of air transportation including the development of hot air balloons, Hindenberg disaster, first flight by the Wright brothers at Kitty Hawk, the introduction of the jet engine, and the use of composite materials. SS2

G. Identify and evaluate **career** opportunities in air transportation (e.g., air traffic controller, commercial pilot, flight attendant) based on interests, talents, and career expectations.

H. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when around or participating in air transportation activities. PH3

I. Design, build, and test model aircraft that addresses design considerations like aerodynamics, stability, control, and guidance.

J. Use common tools, materials, and processes to design, build, test, and modify model aircrafts and to simulate an airplane flight.

K. Describe the advantages, disadvantages, and potential applications of various air transportation systems like airships, gliders, prop planes, jet planes, and helicopters. SC2

L. Describe and forecast the implications of innovative air transportation technologies like STOL, VTOL, SST, and telemetry on competitiveness, air safety, and efficiency. SC2

M. Discriminate between lighter-than-air, prop, jet, and rotary-wing aircrafts.

N. Describe the basic payload, guidance, propulsion, control, and support systems for a given mode of air transportation.

O. Determine the optimum means of transporting a given payload based on departure, destination, cost, time, energy, safety, and environmental considerations.

Suggested Learning Experiences

1. Demonstrate how an airplane wing produces the lift needed to fly. Test a cross section (air foil) of an aircraft wing suspended in a commercial or constructed wind tunnel. Explain how Bernoulli's theories and Newton's third law of motion (every action has an equal and opposite reaction) produces lift. Manipulate the air foil angle of attack and determine the stall angle. Discuss the relationship between angle of attack and lift.

2. Introduce students to the concept of aeronautics. Identify the basic component of an airplane and discuss how each plays a part in flight. Using balsa, foamcore, styrofoam, cardboard, and/or paper, have students make model airplanes. Design considerations should include things like size, weight, wing shape, propulsion system, and control devices. Ask students to explain how application (e.g., military, commercial, private) can affect the design of the aircraft.

3. Discuss how wind tunnels are used to test the laws of aerodynamic and engineering principles. Using a commercial or constructed wind tunnel, have groups of students evaluate and modify the airplane produced during the activity above. Have each group evaluate and inspect their aircraft for structural defects, points of instability, and flaws in aerodynamic design. Have students discuss how wind tunnels can be used to improve things like fuel efficiency, safety, and aerodynamics.

4. Introduce students to the concept of thrust. Using things like a plastic propeller and rubber band, CO_2 cartridge, or solid rocket engine, have students develop a propulsion system for their model airplane. Discuss the consequences of propulsion system failure on various types of aircraft. Have students evaluate efforts to make air transportation even faster than it is today.

5. Discuss how ailerons, elevators, and rudders are used to control an aircraft in flight. Have each student install and/or manipulate control devices that will enable their model plane to fly straight, bank right or left, and increase or decrease altitude. Conduct a competition modeled after the International Paper Airplane Contest to determine whose airplane flies the furthest. Have students explain how weight, thrust, flight path, wing span, and control systems affect the distance traveled.

6. Introduce students to the concept of computer flight simulation. Using a computer and one of the popular flight simulation pro-

grams, have each student perform common flight maneuvers (e.g., take-off, bank, land) for an assigned flight plan. Possible flight plans could include things like using a specific type of aircraft, flying at night, landing at various airports, or maneuvering around obstacles, or flying over various types of terrain. Have students discuss the role of flight simulators in training and updating pilots.

7. Discuss how airplanes use lift and drag to maintain altitude and carry a payload. Using materials like balsa, plastic, string, and paper, have small groups of students design, build, and test model gliders that will carry an assigned payload from a given elevation to a specific target on the ground. On a windy day, have students launch their model aircrafts from an upper story window or the top of the football bleachers to a large target several yards below. Award points based on how close they can get their airplane to the center of the target. Have students identify and describe the relationship between things like flight duration, wing span, payload weight, and wing shape.

8. Introduce students to the concept of lighter-than-air vehicles. Using materials like glue, black garbage bags, clear plastic, and kite string, have small groups of students design, build, and test a hot air balloon that uses solar energy and/or a hair dryer to create lift. Ask students to explain why lighter-than-air vehicles are not widely used. Have students forecast how lighter-than-air vehicles might be used in the future.

9. Introduce students to the concept of rotary-wing aircraft. Using things like a rubber band for a power source, a piece of cardboard for a stabilizer, balsa wood for a fuselage, and a propeller to provide lift, have a group of students design, build, and test a model helicopter. Ask students to compare applications for helicopters and airplanes. Have students discuss how experimental aircrafts using short takeoff and landing (STOL) and vertical takeoff and landing (VTOL) technologies could change air transportation systems in the future.

10. Introduce students to the concept of airport design. Using materials like construction paper, cardboard, foamcore, plastic cups, straws, and glue, have a small group of students design, build, and present an architectural model for a rural, metropolitan, commercial, and/or private airport. Each model should include features like a passenger terminal, runways, taxiways, air traffic control, people-moving systems, parking, and hangers. Have each group present how their airport design addresses important considerations like land utilization, noise pollution, safety, expansion, and traffic. Ask students to discuss the importance of long term planning when designing air transportation facilities.

11. Discuss the milestones in the history and evolution of air transportation technology. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

12. Discuss the career opportunities in air transportation technology. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to air transportation technology. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

Suggested Learning Objectives

Upon completion of the Space Transportation Technology unit, students will be able to:

A. Define and properly use common space transportation **terminology** like lunar module, command module, deceleration, tether, flight trajectory, pitch, yaw, perigee, suborbital, jettison, escape velocity, cosmonaut, airlock, insertion burn, refurbish, and geosynchronous.

B. Identify the basic **applications** for space transportation including things like deploying communication satellites, collecting scientific data, conducting experiments in space, and exploring the other galaxies.

C. Describe the societal and environmental **impacts** associated with space transportation activities like the creation of new technologies, improving international communication systems, space pollution, and utilization of financial, human, and material resources. SC2

D. Describe the **processes** used in space transportation like launching, docking, landing, exploring, stabilizing, deploying, staging, descending, ascending, orbiting, and recovering.

E. Describe the basic human, material, natural, informational, financial, and technological **resources** associated with space transportation processes and enterprises (e.g., mission specialists, liquid hydrogen, federal funding).

F. Describe the major milestones in the **history** and evolution of space transportation technology including the development of the first liquid fueled rocket by Dr. Robert Goddard; the launching of Sputnik I in 1957; the accomplishments made by the Mercury, Gemini, and Apollo projects; the information gathered by the Mariner, Pioneer, and Viking deep space probes; the impact of the space shuttle disaster; and the conceptualization of orbiting space stations. SS2

G. Identify, describe, and evaluate **career** opportunities related to space transportation technologies (e.g., mission specialist, aerospace engineer, astronomer) based on their interest, talents, and career expectations.

H. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when making, testing, launching, and recovering model rockets around or participating in space transportation activities.

I. Describe the basic payload, guidance, propulsion, control, and support systems for a given mode of space transportation.

J. Design, build, and test a working model space transportation system that features a propulsion, control, guidance, payload, recovery, and support system.

K. Use common tools, materials and techniques to design, build and test model space transportation systems; to collect and interpret data; and to simulate space travel.

L. Describe the advantages and disadvantages of various types of space transportation vehicles including rockets, space probes, and space shuttles. SC2

M. Evaluate the pros and cons associated with the exploration and development of space for scientific, military, and commercial applications. SC2

N. Forecast the role of space transportation in the development of futuristic manufacturing, communication, construction, transportation, and energy utilization technologies. SC2

O. Explain and demonstrate how scientific concepts like gravity, potential energy, kinetic energy, and Newton's third law of motion apply to rocket engines and space transportation systems. SC1

P. Use a variety of mathematical principles and techniques to determine the relationship between variables like weight, velocity, attitude, and thrust. MA4

Suggested Learning Experiences

1. Introduce students to basic propulsion, control, and payload systems on various kinds of space vehicles. Using commercial and/or constructed components (e.g., body tube, fins, nose cones, streamers), have students design and build model rockets. Each design should include things like a payload cavity, a recovery system, tuned fins, an engine mount, and identification markings. Have students compare and contrast the propulsion, control and payload system on their rocket with those on real rockets. Ask students to describe how rocket designs have changed over the years and how space vehicles might look in the future.

2. Discuss the techniques to be used to test rockets and their components. Have each student test the stability of their rocket by attaching a string to its center of gravity and swinging the rocket overhead in a circular path. Have students modify unstable rockets by enlarging fins or adding weight to nose cones. Consider using a commercial or constructed wind tunnel to conduct additional tests. Ask students to explain why quality control and tests are so important to space transport technology.

3. Introduce students to the procedures used to launch space vehicles. Have each student design and complete a pre-launch check list. The checklist should include things like safety procedures, rocket components, launch area specifications, engine requirements, and weather conditions. When the rocket has completed the pre-launch procedures in a large open area, have the students conduct countdown procedures and launch model rockets. Discuss how automated systems are used to monitor pre-launch procedures of real rockets.

4. Discuss how rockets are tracked during space missions. Using a commercial or constructed tracking device, and a teacher-prepared worksheet, have students measure the angle between launch pad and the rocket's peak altitude from a given base line distance. Using the data collected, have students calculate the altitude achieved by their rocket. Have students discuss the consequences of a poor tracking system on crew safety and future missions.
5. Explain why space vehicles use staging to overcome the forces of gravity and achieve an orbit. Discuss how space vehicle design and propulsion systems are influenced by their applications. Have students weigh their rockets, launch their rockets using a small engine, track their rockets' flight, and determine the altitude achieved. After recovering their rocket, have them repeat the procedure using a larger engine. Have students determine the relationship between engine thrust (size), the vehicle and payload weight, and vehicle's altitude and flight duration.
6. Explain how computer simulations are used to test space flight procedures and train astronauts and mission specialists. Discuss how computers are used to monitor and control space vehicles. Using one of the popular computer simulation programs, have students conduct a simulated space flight. Each space flight should include things like launching a vehicle, establishing an orbit, docking with a space station, retrieving or deploying satellites, and conducting re-entry and recovery procedures. Ask students to describe the impact of computer technology on the development and implementation of space transportation systems.
7. Discuss how a lunar rover was used to explore the surface of the moon. Using materials like hobby motors, photovoltaic, model car wheels, and batteries, have students design, build, test, and present a model lunar vehicle. Each presentation should include an explanation of the vehicle's communication, life support, propulsion, control, and payload systems. Ask students to discuss how lunar vehicles can affect things like mission flexibility and duration.
8. Discuss the milestones in the history and evolution of space transportation technology. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.
9. Discuss the career opportunities in space transportation technology. Include occupations at the non-skilled, semiskilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to space transportation technology. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

Addresses

The following list of addresses is provided for teachers desiring additional information:

Illinois Vocational Curriculum Center (IVCC)
Sangamon State University F-2
Springfield, IL 62708
800/252-8533

American Vocational Association (AVA)
828 South 2nd Street
Room 403
Springfield, IL 62704
217/433-0815

Curriculum Publications Clearinghouse
Western Illinois University
Horrabin Hall 46
Macomb, IL 61455
800/322-3905

Center for Implementing Technology Education
Department of Industry & Technology
Ball State University
Muncie, IN 47306

Technology Student Association (TSA)
University of Illinois
Department of Vocational & Technical Education
1310 S. Sixth Street
Champaign, IL 61820

Illinois Vocational Association (IVA)
44 Emporia Avenue
Springfield, IL 62702

American Technology Student Association (ATSA)
1908 Association Drive
Reston, VA 22091
703/860-9000

International Technology Education Association (ITEA)
1914 Association Drive
Reston, VA 22091

Illinois Industrial Technology Education Association (IITEA)
44 Emporia Avenue
Springfield, IL 62702

Department of Adult, Vocational and Technical Education
Program Improvement Section
100 North First Street
Springfield, IL 62777

U.S. Department of Transportation
Office of Public Affairs
Washington, DC 20590

Carol Henry
Mix Coordinator
Gregg Division - McGraw Hill Book Company
New York, NY 10020
(314) 256-2222
The Technology Link

NASA Lewis Research Center
Teacher Resource Center
Mail Stop 8-1
Cleveland, OH 44135 (216)433-2017

Software

The following partial list of software is offered to help teachers identify programs having potential for application in technology courses.

ROBCAT
Computer Applications Tomorrow
P. O. Box 4093
Carsbad, CA 92008

ROBOTICS KIT
The Teacher's Laboratory, Inc.
P.O. Box 6480
214 Main Street
Brattleboro, VT 05301

TRAINS
Spinnaker Software Corp.
215 First Street
Cambridge, MA 02142

KENNEDY APPROACH
MicroProse Software
120 Lakefront Drive
Hunt Valley, MD 21030

FLIGHT SYMULATOR
SATURN NAVIGATOR
SubLogic Corporation
210 W. Springfield
Champaign, IL 61820

RENDEZVOUS
TRANQUILITY BASE
EduWare, Inc.
185 Berry Street
San Francisco, Ca 94107

SPACE STATION
EduTech
303 Lamartine Street
Jamaica Plain, MA 02130

FLIGHT - AERODYNAMICS OF MODEL ROCKETS
IN SEARCH OF SPACE - INTRODUCTION TO MODEL ROCKETS
PHYSICS OF MODEL ROCKETS
Hearlihy & Co.
714 W. Columbia Street
Springfield, OH 45501

GLIDE PATH
Human Relations Media
175 Tompkins Avenue
Pleasantville, NY 10570-9973

SPACE M+A+X
Final Frontier Software
18307 Burbank Blvd., Suite 108
Tarzana, CA 91356

ROBOT ODYSSEY I
The Learning Company
545 Middlefield Road
Suite 170
Menlo Park, CA 94025

GEARS: STRATEGIES IN PROBLEM SOLVING
Sunburst Communications
30 Washington Ave.
Pleasantville, NY 10570

Books

The following textbooks will contain information that will help teachers prepare to teach technology courses:

Bame, E. A., & Cummings, P. (2nd. ed.). (1980). *Exploring technology.* Worcester: Davis.

Bolhn, R. C., Fales, J., MacDonald, A. J., & Kuetemeyer, V. F. (1986). *Energy, power and transportation technology.* Encino: Glencoe.

Deane, Q. (Ed.). (1982). *How it works.* New York: Grenwich House.

DeOld, A. R., Sheets, E., & Alexander, W. (1986). *Transportation: The technology of moving people and products.* Worcester: Davis

DeVore, P. W. (Ed.). (1983). *Introduction to transportation.* Worcester: Davis.

Fales, J. F., Kuetemeyer, V. F., Brusic, S. K. (1988). *Technology: Today and tomorrow.* Mission Hills, CA: Glencoe.

Feldman, A., & Gunston, B. (1980). *Technology at work.* New York: Facts on File.

Goetsch, D. L., & Nelson, J. A. (1987). *Technology and you.* Albany: Delmar.

Hacker, M., & Barden, R. A. (1988). *Living with technology.* Albany: Delmar.

Hacker, M., & Barden, R. A. (1987). *Technology in your world.* Albany: Delmar.

Harms, H. (Ed.). (1988). *Energy, power, and transportation technology activities.* Albany: Delmar.

Harpur, P. (Ed.). (1982). *The timetable of technology.* New York: Hearst.

Kline, R. (1985). *The ultimate paper airplane.* New York: Simon and Schuster.

Minton, G. D., & Minton, B. K. (1987). *Teaching technology to children.* Worcester: Davis.

Ninomiya, Y. (1980). *Whitewings* [Paper airplanes]. Osaka, Japan: AG.

Potter, T. (1984). *How to make computer-controlled robots. For Commodore 64 & VIC 20.* London: Usborne.

Schwaller, A. E. (1989). *Transportation, energy, power technology.* Albany: Delmar

Taylor, P. (1982). *The kids' whole future catalog.* New York: Random House.

Todd, R., McCrory, D., & Todd, K. (1985). *Understanding and using technology.* Worcester: Davis.

Williams, C. F., Badrkhan, K. S., & Daggett, W. R. (1985). *Technology for tomorrow.* Cincinnati: South Western.

Williams, C. F., Badrkhan, K. S., & Daggett, W. R. (1985). *Technology at work.* Cincinnati: South Western.

Williams, R. (1984). *Building and flying indoor model airplanes.* Salt Lake City: Peregrine Smith Books.

Manuals

Manuals available from the Curriculum Publications Clearinghouse, Western Illinois University, Horrabin Hall 46, Macomb, IL 61455, 800/322-3905

- Strategies for Problem Solving

- Transition Training: Manual for Personal Growth, Development and Self-Improvement
- The Vocational Ethics Manual
- Generalizable Communications Skills Assessment: User Manual
- Generalizable Communications Skills Assessment: Resource Directory
- Generalizable Interpersonal Skills Assessment: User Manual
- Generalizable Interpersonal Skills Assessment: Resource Directory
- Generalizable Mathematics Skills Assessment: User Manual
- Generalizable Mathematics Skills Assessment: Resource Directory
- Generalizable Reasoning Skills: User Manual
- Generalizable Reasoning Skills: Resource Directory

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ISBE/DAVTE Research and Development Section
Jerry Ohare

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Ron Engstrom
John Kopatz
Chuck Windhorst

Illinois Plan Project Staff

Franzie Loepp, Co-Director	Illinois State University
Kenneth Welty, Co-Director	Illinois State University
Dennis Gallo, Research Associate	Illinois State University
Kathy Hatch, Administrative Assistant	Illinois State University

Self Empowerment Project Staff

Pamela Miller, Project Development Specialist	Southern Illinois University
Joseph Karmos, Professor	Southern Illinois University
Harry Daniels, Professor	Southern Illinois University

Consulting Teachers
Dave Bergland, Farmington East High School
Rod Bourne, Morrisonville High School
Harry Carlson, Libertyville High School
William Conroy, Chicago Board of Education
Bob Freeman, Buffalo Grove High School
Dennis Gallo, O'Fallon High School
Ken Heitz, Bradley-Bourbonais High School
Mark Hobson, Normal Community High School
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Tony Lenoir, Evanston High School
Fred Lipp, Williamsville High School
Norm Meier, Neward High School
Leonard Modder, Chicago Board of Education
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David Peters, Bradley-Bourbonnais High School
Steve Pille, Farmington East High School

Illinois
State Board of
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100 North First Street
Springfield, Illinois 62777

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